Atomic Energy Control Board
P.O. Box 1046
Ottawa, Canada
K1P 5S9

Commission de contrôle de l'énergie atomique
C.P. 1046
Ottawa, Canada
K1P 5S9

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AGING AND MALFUNCTION OF VALVES IN CANDU SPECIAL SAFETY SYSTEMS - PHASE 1 -

by

NUMET ENGINEERING LTD/
SPECTRUM ENGINEERING CORP. LTD

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AGING AND MALFUNCTION OF VALVES IN CANDU SPECIAL SAFETY SYSTEMS

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ABSTRACT

Aging and wear related valve malfunctions have been reported in American nuclear generating systems. This report documents the first attempt to study these phenomena on a global basis in Canadian nuclear power plants.

A general methodology outlines an approach to this type of study which is amenable to use within existing information structures.

Nuclear regulatory requirements which influence the testing of valves in Canadian nuclear power plants are reviewed. The reporting systems which emanate from these requirements are discussed and sources of valve failure data are reviewed. It is determined that modifications to existing failure reporting systems are required before practical means of collecting data necessary for the analysis of age related valve malfunctions can be developed.

In spite of limitations in reported failure data, a partial data base is compiled for valve failures in Special Safety Systems of domestic nuclear plants. Data are reported for the period 1982 to 1986. The valve population and basic parameters of each valve such as type, operator, function, etc., and the reported failures against this population are compiled and reviewed for evidence of time dependent versus random failure trends. Results suggest that there is no clear age related failure trend. In fact, some systems and stations experienced a reduction in failure rates with years of servicing, suggesting that some earlier generic valve problems may have been solved.

Present inspection, test, and maintenance practices are reviewed and their effectiveness for purposes of predicting or preventing incipient failures is assessed to be of moderate value. Modern failure prevention methods are highlighted and their applicability discussed.

The extensive scope of this study and present status of failure reporting systems limit the depth to which issues can be discussed and the quantity and quality of data which can be collected and analyzed. The report is intended to service as a basis for subsequent work.

RÉSUMÉ

Le vieillissement et l'usure reliés au mauvais fonctionnement des soupapes ont été décelés dans les systèmes électronucléaires américains. Le présent rapport documente la première tentative d'étudier ce phénomène de façon globale dans les centrales électronucléaires canadiennes.

Une méthodologie générale indique les grandes lignes d'une approche de ce type d'étude qui est utilisable à l'intérieur des structures d'information existantes.

Les exigences de la réglementation nucléaire qui touchent les épreuves des soupapes dans les centrales électronucléaires canadiennes sont examinées. Les systèmes de rapport qui découlent de ces exigences sont discutés de même que les sources de données sur les défaillances des soupapes. On a déterminé que les modifications aux systèmes actuels de rapport des défaillances sont nécessaires avant de pouvoir mettre au point des moyens pratiques de collecte des données nécessaires pour l'analyse des défaillances des soupapes attribuables au vieillissement.

En dépit des données limitées sur les défaillances rapportées, une base de données partielle est compilée pour les défaillances de soupapes dans les systèmes de sûreté spéciaux des centrales nucléaires canadiennes. Les données sont rapportées entre 1982 et 1986. Les soupapes et les paramètres de base de chaque soupape, comme le type, l'opérateur, la fonction, etc., ainsi que les défaillances rapportées par rapport à chacune, sont compilés et examinés pour y déceler des modèles chronologiques plutôt qu'aléatoires. Les résultats semblent montrer qu'il n'existe pas de modèle précis de défaillance lié au vieillissement. En fait, certains systèmes et certaines centrales ont connu un taux de défaillance inférieur après des années d'entretien, laissant ainsi entendre que certains problèmes génériques antérieurs de soupapes pourraient avoir été résolus.

Les inspections, épreuves et pratiques de maintenance actuelles sont examinées et leur efficacité à prévoir ou à prévenir les débuts de défaillance est évaluée comme étant moyenne. Les méthodes modernes de prévention des défaillances sont mises en évidence et leur applicabilité est discutée.

La grande étendue de la présente étude et l'état actuel des systèmes de rapport des défaillances limitent la profondeur de la discussion des problèmes, ainsi que la quantité et la qualité des données qui peuvent être recueillies et analysées. Le rapport a pour but de servir de base à des travaux ultérieurs.

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A. INTRODUCTION

1. BACKGROUND

The most common type of failure in CANDU nuclear power plants (NPPs) involves valve malfunctions [1]. Valve problems have similarly been a major source of operational difficulties in pressurized nuclear systems according to US experience [2].

Valve malfunctions often arise due to degradation in service and it has been suggested that age related-degradation remains generally undetected by the present inspection programs stipulated by the codes and regulatory agencies [2].

As part of the continued development of effective regulatory requirements associated with reactor safety, the Atomic Energy Control Board (AECB) commissioned this study to examine aging related valve malfunctions in CANDU NPPs. For reasons later discussed, the study focuses on the valves of the Special Safety Systems (SSSs).

The study was carried out jointly by Numet Engineering Ltd and Spectrum Engineering Corp. Ltd, between August 87 and September 88.

2. SCOPE

2.1 Objectives of Study

The ultimate objectives of the study were defined as follows:

a) To identify operational and environmental stressors causing time-dependent degradation of specified valves used in CANDU NPPs.

b) To identify failure modes and causes resulting from aging and service wear of the valves.

c) To assess the effectiveness of current inspection, testing, condition monitoring and maintenance methods/practices in terms of their capability to detect and mitigate aging degradation before a valve failure occurs.

d) To identify practical and cost-effective precursor indicators of potential failure modes.

e) To provide guidance for selection of practical and cost-effective inspection, testing, condition monitoring, and maintenance methods capable of revealing degradation trends prior to valve failures.

f) To recommend additional studies or tests which may be required to better understand, effectively detect and mitigate time-dependent degradation of the valves before the loss of function.

These objectives while serving the AECB in the exercise of its mandate are also clearly of interest to the operators of NPPs who have both safety and financial interests in preventing failures of NPP components, most particularly those associated with the SSSs.

2.2 Methodology

The previously stated objectives require that a considerable amount of data associated with particular valve failures be collected and analyzed.

Since at the outset there was no clear indication of what data might be available or how it could be obtained, a general methodology was developed. This methodology was designed to provide a structured approach to the identification, collection, and analysis of information required for this study.

In reviewing the methodology to follow, the reader is reminded of the size of the organizations involved, complexity of their systems, and of the volume of information which is being addressed. Thus, a simple "review of regulatory requirements, codes and standards..." could in itself consume the entire resources available for this study if improperly approached.

The methodology was developed around five broad categories, namely:

a) Review of Regulations Influencing Valve Inspection and Testing

b) Data Identification and Collection

c) Data Compilation and Analysis

d) Review of Current Inspection, Maintenance and Test Practices

e) Recommendations to Improve Failure Detection and Prevention.

The basic purpose and main tasks to be performed under each category are summarized in Tables A-1 through A-5.

It will be seen in the following chapters that the study was severely limited by the disproportionate effort required to assemble data surrounding a valve failure, and by the lack of records on individual valve failures likely to contain the type of information necessary for a failure analysis.

B. REGULATORY REQUIREMENTS, CODES AND STANDARDS

This section describes the regulatory requirements, codes and standards applicable to valves in nuclear power stations in Canada. For comparison purposes, a brief review of the codes and standards used in the U.S. is also provided.

The justification for reviewing these requirements given the context of this study is threefold:

a) Firstly, it is necessary to gain an understanding of the mandatory requirements which drive inspection, test, maintenance, and reporting efforts, before a meaningful assessment of current practice can be performed.

b) Secondly, the regulatory requirements and associated codes and standards dictate in large part what types of records are to be kept and thus provide a structured starting point from which to initiate information gathering.

c) Thirdly, the regulatory requirements, codes, and standards are ultimately the vehicles used by the AECB and station owners to ensure that public interests are safely and practically served. It is therefore through these regulations and standards that improvements in failure prevention can be effected.

1. CANADIAN NUCLEAR REGULATORY REQUIREMENTS

1.1 Federal Regulations

In Canada, the operation of nuclear power stations is governed by the Atomic Energy Control Act which is administered by the Atomic Energy Control Board (AECB). The AECB sets out general performance requirements in the Regulatory Policy Statements, Regulatory Guides, and the Reactor Operating Licences issued to the utilities.

Each utility prepares an Operating Policies and Principles (OP&P) document showing how it intends to meet these general performance requirements. Subject to approval of this and other documents by the AECB, the utility is issued an operating licence.

At this time, three provincial utilities hold Reactor Operating Licenses, namely:

- New Brunswick Electrical Power Commission (NBEPC)
- Ontario Hydro (OH)
- Hydro Quebec (HQ)

A typical licence, Pickering A's, was reviewed for references to requirements of regulatory bodies, codes or standards. While the licence itself does not contain any such references, the OP&P document submitted with the licence application states that "The station shall be operated to conform with all relevant Federal and Provincial regulations".

Licensing requirements commit the utility to test safety-related systems at a frequency acceptable to the AECB to demonstrate that the reliability of the system meets that claimed in the Safety Report and other documents used to support the licence application.

However, specific equipment failures need not be reported unless they result in one of the following reportable events:

- Increased risk to the health and safety of the general public or station operating staff.
- A hazard different in nature or greater in magnitude than previously presented to the AECB.
- Fuel failure or release of prescribed substances, which in the absence of a SSS, would have led to such a failure or release.
- The failure of a SSS to perform as described in the Safety Report or other documents used to support the licence application.

- The failure of two or more parts of a SSS.
- A violation of the conditions of the licence.

Therefore, as seen from the above list, whether or not an equipment failure is reported depends on the consequence of the failure. This practice satisfies the licensing requirements but unfortunately does not support the establishment of a general component failure database since only a partial history of equipment failures is produced for a subset of systems, namely the SSSs and other safety-related systems.

For those reportable equipment related events, the licence requires that adequate records be kept by the utility on the following:

- Operation
- Maintenance
- Test results
- Periodic inspection
- Increased personnel risks
- Personnel radiation exposures
- Release and disposition of prescribed substances.

It is seen here again that the reporting requirements at this level do not produce the detailed data required for future analysis of the failure cause.

Reporting of relevant events, a licence requirement monitored by the AECB, is largely met by the utilities through two reporting systems: Quarterly Technical Reports (QTRs) and Significant Event Reports (SERs). The QTRs provide the AECB with operating data, and equipment or system failure data (mostly for SSSs). The SERs, or Unplanned Events Reports in the NBEPC, report on events which have the potential to undesirably affect safety or production. These reporting systems are reviewed in greater detail in Section D of this report.

In summary, federal nuclear regulatory requirements refer only indirectly to valve testing by requiring the utilities to demonstrate acceptable availability of SSSs. The emphasis is on system availability and consequently detailed failure information for a particular piece of equipment (e.g. cause of failure, failure mode, failure mechanism, process parameters at time of failure, etc.) is often not reported or is so general as to be of limited usefulness to studies of the present type.

1.2 Provincial Regulations

At the provincial level, in addition to complying with the requirements of their current Reactor Operating Licence, each NPP must comply with the requirements of the provincial body which administers the regulations for boilers and pressure vessels.

The following bodies are charged with this responsibility:

- In New Brunswick: New Brunswick Department of Labour (NBDOL).
- In Ontario: Ministry of Consumer and Corporate Relations (MCCR)
- In Quebec: Ministère du Travail du Quebec (MTQ)

Each provincial body is responsible for periodic inspection of NPPs within their jurisdiction to ensure their safe operation. In all three cases the provincial regulatory requirements make reference to Canadian standards, discussed in the following sub-section, as well as to the requirements of the Boiler and Pressure Vessel Code (B&PVC) of the American Society of Mechanical Engineers (ASME).

At this time the provincial regulatory bodies do not impose additional specific requirements on the NPPs for the inspection, testing, and maintenance of valves, beyond those of the above noted references.

2. CODES AND STANDARDS

2.1 Canadian Standards

Federal Standards relating to nuclear power plant components are prepared by committees from the Canadian Standards Association (CSA), which usually include representatives from all of the utilities and from both levels of Government. Requirements covering the in-service inspection of CANDU valves are addressed in CSA STD CAN3-N285.4-M83, "Periodic Inspection of CANDU Nuclear Power Plant Components".

This standard defines the periodic inspection requirements for pressure retaining parts. The topics covered include:

- Classification of areas to be inspected
- Responsibilities for inspection
- Inspection procedures and techniques
- Frequency of inspection
- Records and documentation
- Evaluation and repair.

Inspection must be carried out by authorized inspectors and includes visual examination, plus various methods of direct and indirect measurement of valve components. Procedures and techniques dictated by various sections of the ASME Boiler and Pressure Vessel Code are referenced where applicable.

The purpose of this standard is to ensure that the integrity of required systems is maintained, in order to prevent the release of radioactive substances to operating personnel or the public. The standard requires that the owner of a nuclear plant prepares a periodic inspection program for each reactor, for submission to the authority enforcing the standard. This document must detail the selection of systems and components for inspection, categories of inspection, frequencies, and techniques proposed.

Included also in the series of standards for nuclear power plants is the Canadian Quality Assurance Standard, N286.5, which dictates requirements for the successful implementation of preventative maintenance programs.

2.2 American Standards

The two most significant non-licensing U.S. regulatory bodies relevant to this study are the American Society of Mechanical Engineers(ASME) and the Institute of Electrical and Electronic Engineers(IEEE). The operator portion of motorized valves is under the jurisdiction of the IEEE, and there is some overlap in jurisdiction between the IEEE and the ASME for the mechanical portions of these valves.[3]

Both bodies dictate qualification requirements for valves referenced in the technical specifications of US nuclear generating stations. These qualification requirements dictate the conditions under which a valve is considered qualified to operate in a particular service.

In order to qualify for installation, a valve type must be subjected to a test program which will simulate actual operating conditions. In order to maintain this qualification status, certain procedures regarding operational testing and maintenance, in-service inspection, and condition evaluation must be followed.[3][4]

ASME B&PVC - Section XI

The ASME B&PVC is referenced by both Canadian and American nuclear regulatory requirements. Section XI, Subsection IWV of this code, entitled "In-Service Inspection of Valves in Nuclear Power Plants", contains rules and requirements (sub-sections IWV-1000 through IWV-6000) for surveillance testing of various classes of valves. The rules cover special safety systems of light-water and gas-cooled NPPs, and are designed to assess the operational readiness of those systems' valves.

Valve types are considered in four categories of functional requirements:

Category A: Only limited seat leakage allowable

Category B: Closed position seat leakage inconsequential

Category C: Self Actuating valves

Category D: Rupture disks or explosively actuated valves.

Requirements for three types of in-service testing are described:

(1) Valve position indicator verification
(2) Valve exercising test
(3) Valve leak rate test

Type (1) tests require simply that accurate indication of valve operation be verified at a maximum of two year intervals.

Type (2) exercise tests require that the operation of valves be observed either during normal operation or during plant shutdown. In either case the observations must be properly logged and recorded. Valves which must be tested during cold shutdowns (i.e. cannot be fully stroked during normal operation) are tested during every shutdown unless the elapsed time between tests is less than 3 months.

In addition to being stroked, power operated valves must also be timed and have their performance compared to previous results and accepted standards. Guidelines for corrective action and/or increased frequency of testing are given for valves which fail this criteria.

Type (3) valve leak tests are performed at a minimum frequency of every two years, unless acceptably low leakage rates can be observed and recorded during normal service. Leakage rates are compared with previously recorded values, or owner specifications if available. Acceptance leakage standards for water or air are given by ASME for use when other criteria are not available.

Corrective actions or additional testing requirements are dictated for failed valves.

ASME Operation & Maintenance Committee

In addition to the ASME B&PVC Section XI, other relevant standards have been published by the ASME "Committee on Operation and Maintenance of Nuclear Power Plant Components". The Committee's mandate is to "develop, maintain and review codes and standards that are considered necessary for the safe and efficient operation and maintenance of nuclear power plants". [5]

This committee is composed of owners, operators, manufacturers, designers, constructors, regulatory agencies, insurance companies, and general interest groups.

Published standards relevant to this study include:

- OM-01 "Requirements of Inservice Performance testing of pressure relief devices".
- OM-08 "Periodic and performance testing of MOVs".
- OM-10 "Performance testing of valves.

Relevant standards currently in draft stage include:

- OM-XX "Vibration Monitoring of Valves"
- OM-XX "Requirements for periodic performance testing and monitoring of power operated relief valves and actuating systems".

The emphasis of the new committee guidelines is on on-line monitoring systems such as acoustic and mechanical vibration testing, plus preventative maintenance tests or inspections which monitor changes in equipment behavior from original baseline data.

Miscellaneous US Standards

Numerous other non-nuclear agencies or bodies publish standards which supply useful information on inspection, testing, maintenance, or condition monitoring of valves. The US military Std. MIL-STD-1523 gives directives on control of age sensitive elastomeric materials for example, and the American National Standards Institute(ANSI) publishes a standard on the qualification of power-operated active valve assemblies.

A partial list of other sources of possible interest includes:

ANS - American Nuclear Society
API - American Petroleum Institute
ASLE - American Society of Lubricating Engineers
ASTM - American Society for Testing and Materials
EIA - Electronics Industries Association
ISA - Instrument Society of America
NEMA - National Electrical Manufacturers Association
UL - Underwriters Laboratory

Additional sources may be found from the US Department of Defense Index of Specifications and Standards.

C. VALVE DATA: REQUIREMENTS, SOURCES, STATISTICS

This section outlines the types of data necessary for an analysis of aging/wear related valve malfunctions, the sources and methods currently available for retrieval of such data, and the data collection results.

1. DATA REQUIREMENTS

Data requirements for a study of this type may be grouped into three categories:

a) Population Data
b) Failure Data
c) Design Data

Population data is obtained by defining a group of valves of interest and uniquely identifying the valves within that group as well as recording their basic characteristics.

Failure data is obtained by extracting, from a broad set of information on failed nuclear components, all relevant failure information specific to valves within the study group.

Design data consists of a collection of fundamental information regarding the valve types, their design parameters, operating conditions, environmental stressors, etc..

Data from the above three categories was compiled into a database to facilitate statistical analysis. The database contains three parts corresponding to the above categories and is reproduced in Appendix B for reference purposes.

The following sections describe in greater detail the requirements for each data category, the sources found most appropriate for such data, and the basic statistics which were derived from the database.

2. POPULATION DATA

The valve population selected for study was limited to the main valves of the SSSs in domestic CANDU NPPs. This group of valves was judged as offering the best potential for availability of failure data. This group is also of significant operational importance and contains a relatively large number of valves.

A more extensive valve population involving other systems may have been desirable but would have exceeded available resources. However, as evidenced in the following sections, it is likely that a more extensive population would suffer from even greater limitations than that of the selected population and thus would contribute marginally at best to the present study.

2.1 Defining a Valve Population

2.1.1 Sites

All four major domestic NGS installations were considered, namely:

(i) Pickering NGS, including sites A & B, for a total of eight units - Ont.
(ii) Bruce NGS, including sites A & B, for a total of eight units - Ont.
(iii) Gentilly 2 NGS, in Quebec, one unit.
(iv) Point Lepreau NGS, in New Brunswick, one unit.

A total of 18 reactor units are therefore represented in the study.

2.1.2 Systems

The main valves contained in the Special Safety Systems of the above mentioned sites formed the study population. Secondary valves used only for test purposes or as pilots to certain main valves are relatively few, of lesser consequence, and thus were not considered.

The operational readiness of the SSSs is critical to safety. Consequently inspection and test efforts tend to be concentrated on these systems thereby creating more data than would be available for other systems. Furthermore, by virtue of their purpose to minimize the possibility of a release of radioactive substances, these systems contain relatively large numbers of isolating and check valves and, to a lesser extent, control and pressure relief valves. The SSSs are therefore a logical choice for a study of this nature.

Four Special Safety Systems are found in CANDU nuclear power plants:

(i) Shutdown System One (SDS1)
(ii) Shutdown System Two (SDS2)
(iii) Emergency Core Cooling (ECC or ECI)
(iv) Containment (CONT)

The Emergency Water Supply System was also considered as a candidate safety-related system for inclusion in this study. However, the sources of valve failure data consulted did not include failures for this system and this system was therefore excluded from further consideration.

SDS1

In the absence of adequate corrective action from the protective process systems, Shutdown System #1 is the preferred method of rapidly reducing reactor power in the event of potentially unsafe reactor operating conditions. This system involves the release of shutoff rods which fall by gravity into the calandria. In Pickering 'A', which does not have a second independent shutdown system, a moderator dump is provided in addition to the action of the shutoff rods. Thus, other than the moderator dump valves at Pickering 'A', there are no valves of consequence in the operational portion of SDS1, the operating components being primarily electro-mechanical and small isolation valves used for testing. This system therefore does not feature in the valve population or valve failure databases.

SDS2

An alternative method of reducing reactor power quickly is provided by Shutdown System #2. In this system, high pressure helium is used to inject moderator poison (a gadolinium nitrate solution) into the moderator through a number of injection tubes. The flow of helium is initiated by pneumatic isolating valves.

Other valve types found in SDS2 include check, isolating, and control valves.

ECC

The Emergency Core Cooling system (referred to as the emergency coolant injection system or ECI in OH stations) has high pressure and low pressure stages. Earlier plants, principally Pickering 'A', did not include a high pressure ECI (HPECI) system during the period covered by this study (1982-1986).

In the high pressure stage, water is injected into the primary heat transport system from ECC storage tanks using pressurized air or nitrogen. In the low pressure stage, water is supplied initially from a suitable storage tank and, when that source is depleted, water is recirculated from the reactor building sump, pumped through heat exchangers and returned to the heat transport system.

Check, isolating, control, and pressure relief valves are found in this system, with valves being exposed to D_2O, H_2O, steam, air, and nitrogen. The most common valves are again the isolating valves, in particular at Bruce sites which have a significantly larger quantity of isolating valves than Pickering 'A'. This highlights the variation in the design of the ECI system at different plants.

Containment

The Containment system includes dousing, local air coolers, personnel and equipment airlocks, and containment isolation systems.

Airlocks allow pressure controlled access to the reactor building which is held slightly below atmospheric pressure. The local air coolers condense steam that may be produced from heat transport system leaks; large leaks initiate dousing and/or containment isolation.

Difficulties were encountered when it was attempted to define which valves were considered to be part of the containment system since the containment function is distributed throughout several process systems each with their own flowsheets. As a result, all Containment subsystems could not be reviewed within the scope of the present study. However, a reasonable representation was made possible by reviewing the Containment Isolation and Dousing subsystems. These two subsystems contain the majority of safety-related valves and are included in the scope of this study.

2.1.3 Valve Types

Four valve functional types were considered for this study:

i) Isolation Valves
ii) Control Valves
iii) Pressure Relief Valves
iv) Check Valves

Data collection revolved around the main process valves plus their actuators and associated torque and limit control switches where applicable.

In order to allow later cross-referencing with failure data, each valve must be uniquely identified, located, and classified. In addition, any information on the valve or its operating characteristics uncovered during the valve count should be recorded.

As a minimum, valves should be described in terms of their function and type. Other design information which should be recorded includes size, materials of construction, operating pressures and temperatures, and a description of major components.

2.2 Sources of Valve Population Data

Based on numerous requests and interviews, and contrary to expectations, listings identifying the valves within a site's SSSs do not appear to be available at this time. Valve population data had to be compiled for SDS2 and ECC/ECI systems, and some containment systems, by reviewing individual flowsheets while reference to reliability models and studies in the QTRs was necessary for containment systems at OH sites.

Flowsheets for all sites of interest were reviewed, except for Gentilly. The valve population for Gentilly was assumed to be equal to that of Point Lepreau and thus Point Lepreau's figures were duplicated to obtain Gentilly's valve count.

The most convenient source to identify valves within SDS2 and ECC/ECI systems was found to be operational flowsheets. A brief discussion comparing operational versus design flowsheets as sources of valve design data is given in Section 4 Design Data.

The operational flowsheets provided information on some or all of the following:

i) Plant, Site and Unit
ii) System
iii) USI and Component Code
iv) Valve Function
v) Valve Type
vi) Actuator Type

Valve location and identification were always provided. Valve function was usually available, and valve type sometimes apparent. In some cases where an actuator was included, its type could be discerned. Practice varied from site to site and sometimes from system to system within the same site, regarding the type of information shown on operational flowsheets.

As previously discussed, difficulties were encountered in attempting to define the valves considered part of the Containment system. The major valves in the Containment Isolation systems at the Ontario Hydro stations were identified by referring to various containment reliability models and studies. These documents were carefully selected for this purpose by Ontario Hydro staff in the RMEP division.

Containment Isolation valves for the Point Lepreau and Gentilly 2 sites were selected by referring to the Operational flowsheet for Point Lepreau. The major valves in the system are readily identified by following each piping section as it passes through the containment wall. The Containment Isolation system at Gentilly 2 is similar to that at Point Lepreau and it was considered identical for the purposes of population statistics.

The Dousing systems at the Pickering and Bruce sites do not have any valves that take an active part in their emergency operation. Their valve count as a result was zero.

The major valves in the Dousing system at Point Lepreau and Gentilly 2 was identified by inspection of the Dousing operational flowsheet for Point Lepreau. The Dousing system at Gentilly 2 was considered identical to that at Point Lepreau for purposes of valve population.

Table C-1 contains a summary of the flowsheets reviewed.

2.3 Valve Population Statistics

The total count of valves for sites and systems considered in this study is 1995, distributed as follows:

Pickering A - 65 valves

Pickering B - 542 "

Bruce A - 483 "

Bruce B - 525 "

Point Lepreau - 190 "

Gentilly - 190 "

This total comprises 1034 ECC/ECI valves, 774 SDS2 valves and 187 containment valves.

Figures A-1-1 through A-1-5 presented in Appendix A indicate the quantity and/or distribution of valves by the following parameters:

- Site
- System
- Function
- Type
- Actuator

The main points illustrated by each graph are summarized below.

Figure A-1-1: As expected, Bruce 'A' & 'B' and Pickering 'B' have the greatest number of valves per site although Point Lepreau and Gentilly have more valves per unit. The small number of valves in the Pickering 'A' population is due to the lack of a HPECI system at that station during the period covered by the study.

Figure A-1-2: Approximately half of all valves in the valve population are in the ECC/ECI system, 39% in SDS2 with the remaining 9% in CONT. This reflects the relative complexity of the ECC/ECI system piping compared with the other safety systems.

Figure A-1-3: Grouped by function, isolating valves are the most common in all systems followed by check valves.

Figure A-1-4: By type, the largest segments of known valves are globe valves (16%) and gate valves (18%). The valve type for a large number of valves (48%) somewhat surprisingly could not be determined from the documents reviewed.

Figure A-1-5: Of known valve actuator types, manually operated valves are the most widely used (37%) with air operated valves next (22%). In approximately 24% of the cases, the method of actuation could not be determined from the documents reviewed.*

3. FAILURE DATA

The primary objectives of this study include the collection and analysis of failure information pertaining to a selected group of valves. Without adequate information about the failure, subsequent attempts at analyzing valve failures for evidence of time dependent degradation or to establish causal relationships between failures and potential stressors are severely limited.

The extraction of failure related information for this study absorbed the greatest portion of available resources and produced disappointingly little of the information necessary to support a sound technical and statistical evaluation of the results.

This situation stems from fundamental limitations in the way, and reasons for which, failure data is recorded and reported in domestic NPPs. Further attempts at similar studies are likely to be hampered by the same limitations. For this reason, the available sources of failure data, their contents, and limitations, are addressed in some detail both in this chapter and in Chapter D.

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* Note that any missing Valve Population Data was also sought from the Design Data and Failure Data sources.

3.1 Failure Data Requirements and Definitions

Ideally, for each valve failure, recorded information should include as a minimum:

- Valve Identification (Site, System, Unit, USI and Component Code Number.
- Valve Function and Type
- Failure Date
- Failure Mode
- Failure Symptoms
- Failure Cause (Determined or Probable)
- Method of Discovery
- Process and Environmental Parameters around time of failure
- Remedy
- Identification of Replacement Valve or Component
- Observations

It will be seen from the following sections that much of this information is not recorded at the time of failure (nor is it required to be at present).

Definitions of failure modes, causes, mechanisms, and stressors are provided in Chapter E.

In anticipation of the volume of information to be reviewed, the valve failure data search was limited to the years 1982 through 1986, for the Pickering and Bruce sites only. Both Pickering A and Bruce A were operational throughout this period, except for

Pickering units 1 & 2 which were shut down for retubing from 1983 onward. Pickering B and Bruce B both had units coming on stream from 1983 to 1986, and Gentilly 2 and Point Lepreau went into service in 1983.

3.2 Sources of Valve Failure Data

At present, valve failure data can only be compiled by following lengthy paper chases through a multitude of documents. This must be repeated for each individual valve failure.

As outlined in Chapter B, existing deficiency reporting systems are not intended to answer the needs of studies of the present type. Unfortunately, and in contrast with American practice, no other systems are. At best, a deficiency reporting system may indicate that a failure has occurred, subject to the severity of the failure. From there, it is necessary to track down and review succeeding levels of documentation to identify if any of the required failure data was recorded. These searches must be performed manually either due to restricted accessibility to the database or because the information is not computerized. An overview of potential sources of valve failure information and their interrelationship is provided in Table C-2.

The first source reviewed for failure information was the AECB Significant Event Report(SER) summary database. This database contains a summary of the SER's received from all the reporting facilities. As such, it is not a primary source of information and, unfortunately, it suffers from misleading entries and incorrect failure information. The intent of the database is to record events, not specific component failures, thus it does not contain much of the component-related information needed for a study of the present type.

In order to clarify the information available from the SER database, a number of full SER's were reviewed.

Using the SER references on the sorted database report, the full SERs were consulted to accomplish the following:

- To determine whether any equipment failure had occurred.
- To determine whether a reported loss of valve function was due to a valve failure or the failure of another component (relay, solenoid, etc.) required for its action.
- To complete and standardize the equipment code for the failed valves.
- To identify the possible failed component(s) associated with the SER report entries where no equipment code was given.

In order to determine how effective the database search was in finding valve failures, a number of SERs were reviewed that had not been identified by the sort. This revealed that there were many valve failures of interest that would not be identified in this study if only those SERs selected by this database sort were reviewed. In conclusion, it was decided that all SERs for the years of interest should be reviewed for this study. Due to time and accessibility constraints, only the SERs for Pickering A and B and Bruce A and B were reviewed (this alone represented approximately 40 large binders of information).

In most cases there is enough information in the SER to establish the correct equipment codes although in several instances it was noted that equipment codes had been misassigned. This is not possible from the SER database due to the inherent lack of detail.

After fully reviewing the SER system for failed valve information, the resulting data was too small in population and too sparse in details to be of use in a study of this type. In order to resolve this situation it was decided to review all the QTRs for the facilities and years of interest.

Both SER's and QTR's were accessed at OH's main reference center.

The following failure data was extracted with varying success from a combination of SERs and QTRs:

i) Date and Location
ii) USI and component code
iii) Failure mode
iv) Failure Cause
v) Valve type
vi) Valve function
vii) Actuator type
viii) Method Fault discovery

Date, location, and valve identification were always available. Failure mode, valve function, and actuator type (where applicable) was usually available. Other items were seldom reported.

A more detailed discussion on available sources of valve failure information is given in the following chapter.

3.3 Failure Statistics

The total number of valve failures recorded for the valves identified in the population database during the period 1982-1986 is 145. This includes 7 failures at Pickering 'A', 13 at Pickering 'B', 110 at Bruce 'A', and 15 at Bruce 'B'.

SDS2 systems accounted for 88 failures, followed by ECC/ECI at 42 and Containment with 15.

Pie charts showing the distribution of failures for each heading in the valve failure database may be found in Figures A-2-1 through A-2-12 in Appendix 'A' under "Failure Statistics". This analysis includes failure distributions by:

i) Site (Figure A-2-1)
ii) System (Figure A-2-2)
iii) Function (i.e. isolating, control etc.)
(Figures A-2-3 and A-2-8)
iv) Type (i.e. gate, globe, etc.)
(Figures A-2-4 & A-2-9)
v) Year (Figure A-2-5)
vi) Mode (of failure) (Figures A-2-6, A-2-8 & A-2-9)
vii) Actuator (method of operation) (Figure A-2-7)

Each graph depicts segments which show the fraction of failures for the parameter under consideration, as a percentage of the total number of failures in the database.

The main results illustrated by each graph are summarized below:

Figure A-2-1: Approximately 76% of the reported failures occurred at Bruce A, which is reasonable considering that Bruce A was the only station which had all of its units operational from 1982-86, (period addressed by study) and that the Bruce plant has a significantly larger population of valves than Pickering. The smallest number of reported failures occurred at Pickering A (5%) not surprising considering that only two units were operating for most of the period due to pressure tube replacement.

Figure A-2-2: SDS2 was previously shown (Figure A-1-2) to have fewer valves than ECC . In terms of number of failures however, SDS2 is shown here to have a significantly larger share. This anomaly can be attributed to the large number of problems with one particular valve on all four units of Bruce A, i.e. 31760PRV 7.

Figures A-2-3 and A-2-8: By function, control and isolating valves have the highest number of failures. Most failures for control valves result from 'Improper Operation'*, followed by

* Note that these terms are "as reported" in the data sources.

'Leaking'*. Internal leakage accounts for most failures in isolating, check and pressure relief valves.

Figures A-2-4 and A-2-9: It is clearly evident that globe valves account for the most failures, followed by gate valves, and butterfly valves. There were no reported failures of ball valves.

Figure A-2-5: This figure shows a large increase in number of reported failures between 1984 and 1985, from a low in 1984 of 20 to 32 failures in 1985. The actual increase in valves in service for this period is only 20%, from 1082 in 1984 to 1302 in 1985. The year with the highest number of reported failures was 1986, which had 35 reported failures. Except for the somewhat low number of failures in 1984, the failures were fairly evenly distributed over the 5 year period covered by this study.

Figure A-2-6: This figure presents a breakdown of failures by failure mode. The largest number of failures are attributable to Improper Operation 29% followed by Internal Leakage, at 25%. When combined with 'Leakage', and 'External Leakage', the figure for leakage comes to almost 50%.

Figure A-2-7: Self actuated valves account for a disproportionate share of reported failures (48%).

A more detailed failure analysis, subject to the inherent limitations in available data, is provided in Chapter F.

4. DESIGN DATA

4.1 Valve Design Data Requirements

In order to correlate failure statistics with relevant stressors, certain engineering or design parameters for individual valves are required, including:

- o Valve Type

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* Note that these terms are "as reported" in the data sources.

- o Actuator Type
- o Design Pressure (Static and Differential)
- o Design Temperature
- o Operating Pressure (Max., Min., Ave, Static and Differential)
- o Operating Temperature (Max, Min, Ave)
- o Valve Component Materials
- o Ambient Radiation Levels
- o Ambient Humidity

The availability of such data would allow a multivariate analysis to be performed on the study population, possibly identifying or confirming relationships between suspected stressors (e.g. temperature) and failure modes etc..

4.2 Sources of Valve Design Data

An attempt was made to consolidate all relevant design data on the valves within the study population. Valve data log sheets, as shown in Table C-3, were issued to the various sites along with a listing of valves for which information was being sought.

Unfortunately, the sites were not equipped to supply the design data because of the difficulties involved in retrieving such data and the level of effort required. Again, this information was not available on-line, and thus a manual collection method had to be implemented.

In view of these difficulties, design information for the entire valve population was not collected, simply due to time and economic constraints. Data was collected to the extent possible for the population of valves for which failures had been recorded.

Several sources were reviewed in an attempt to piece together the required data, including:

- o Operational Flowsheets
- o Design Flowsheets

- o Design Manuals
- o Valve Drawings
- o Operating Manuals
- o Commissioning Reports
- o Safety Reports

4.2.1 Operational Flowsheets

Operational flowsheets for the SSSs of each Canadian NGS were reviewed as a possible source of valve design data, with the following findings.

Little engineering detail is included for individual equipment items shown on these flowsheets. Only the information required to understand the fundamental operation of the system is presented.

The valve design information available from these flowsheets varies from one site to the next. Table C-5 summarizes the information available from the various facilities' SSSs operational flowsheets.

Operational flowsheets are revised by the facility periodically to incorporate changes and were found to be a reliable but sparse source of valve design data.

4.2.2 Design Flowsheets

Design flowsheets are produced during the design stage of a nuclear generating station project by the designers of each process system.

For each system the design flowsheets contain the following kinds of line information:

- Identification number
- Size
- Boundaries between seismically and non-seismically qualified sections of pipe

- Location of major pieces of equipment such as pumps, valves, and heat exchangers
- Pressure rating
- Pipe material
- Design process conditions

During a review of these flowsheets it was found that these documents contained little of the required information. In addition, these documents are not maintained up to date or filed to allow easy access. It is apparent that these are not 'working' documents once plant construction is completed.

As a result these flowsheets are not considered to be a reliable source of valve design data.

4.2.3 Design Manuals

Design manuals are produced by the system designer to record detailed information on the system equipment and its operation. They are filed by USI number and so are easily accessed.

Valve design data can be found in data sheets attached as appendices and in the narrative sections of the manual. Retrieving details from the data sheet is a simple task. Of the design manuals reviewed, however, it was found that not all had data sheets attached. The design manuals that had data sheets did not necessarily have them for all valves carrying the same USI as the manual. In addition, some design manuals contained data sheets of equipment with a different USI to that of the manual. These inconsistencies varied from one system to the next for the same facility and from one facility to the next for the same system.

Some design manuals contained detailed valve design data in the body of the text. This information is more difficult to extract because it must be searched out. In addition, the textual information is never as complete as that available from a data sheet.

Another problem encountered was that not all valve USIs had a corresponding design manual with the same USI number. When this occurred, design manuals with a less specific USI were searched. In some cases no suitable design manuals were discovered. In other cases design manuals with the same USI as a valve were reviewed but no reference to the valve could be found.

Some design manuals refer to purchase order items and purchase order numbers, but this potential source of information was not reviewed.

In summary, design manuals are a good, but incomplete source of valve design data, provided a design manual with a data sheet for the valve in question can be found. Once issued, design manuals are not revised to reflect changes in system design or operation, so information obtained from this source could be out of date.

4.2.4 Valve Drawings

Valve drawings are produced by the valve manufacturer and incorporated into the utilities' drawing system by assigning it an appropriate number. These drawings show sectioned views of the valve and its operator and each part is numbered and detailed in a parts list. A table of design and operating process conditions is usually included.

These drawings are potentially a good source of design data but in our review only a few drawings could be located, and the method of access was time consuming and a hit-and-miss affair. Searching for a valve drawing required the scanning of a drawing index with the same USI as the valve, in the chance that a drawing title of potential interest would be found. It was then a matter to review those drawings of interest to determine if they were of a detailed nature. Some detailed valve drawings were illegible.

For the above reasons, valve drawings as presently organized, are not recommended as a suitable source for valve data.

4.2.5 Other Sources

Safety Reports, Operating Manuals, and Commissioning Reports were briefly reviewed, but were found unsuitable for valve data collection.

In summary, design manuals and operational flowsheets were the primary sources of valve design information. As discussed previously, design data was not available for all systems, and information was not available for several important parameters. Information which was not available from the sources reviewed includes the following:

- Installation and In-service date
- Service life (i.e cycles etc.)
- Ambient conditions
- Vibration conditions

4.3 Valve Design Data Statistics

The design data collection for the failed valves of the study population was carried out with partial success. Table C-4 indicates the design parameters for which we were able to obtain information, and with what frequency.

The valve design information was summarized in Part III of the database reproduced in Appendix B.

5. SUMMARY

The sites and systems for which usable data has been collected are:

Valve Population

Sites - Pickering A, Pickering B, Bruce A, Bruce B, Point LePreau, Gentilly 2.

Systems - ECC, SDS2, CONT. (Isolation and Dousing)

Failure Data

Sites - Pickering A, Pickering B, Bruce A, Bruce B.

Systems - ECC, SDS2, CONT.

Design Data

Same as for failure data above, although incomplete.

D. SOURCES OF VALVE FAILURE DATA

This section describes in greater detail the potential sources of information on valve failures in CANDU NPPs, and discusses the usefulness of these sources for a study of the present type.

1. SIGNIFICANT EVENT REPORTS (SER'S)

SERs are written by station staff when a significant event has occurred. The following definition of a significant event is used by OH:

"An unplanned event that causes or has the potential to cause an undesirable impact upon NGD's performance in the key effectiveness areas of Worker Safety, Public Safety, Environmental Protection, Product Quality, and Production Cost" [6]

SERs at OH are produced in two stages. An Immediate SER is written first followed by a Depersonalized SER.

Immediate SERs

Immediate SERs are the first written records of a significant event and are produced within 48 hours of the event.

Immediate SERs were not reviewed due to their confidentiality and also because more readily accessible depersonalized SERs were a preferable alternative.

Depersonalized SERs

Depersonalized SERs are produced in response to every Immediate SER and issued within 7 days of the event.

As a minimum, Depersonalized SERs contain all the information in the Immediate SERs except that personnel names are deleted and they are classified Commercial. The following points are addressed specifically:

- An event summary.
- Conditions prior to the event.

- Actions taken during and after the event.
- Whether or not the event is considered to be a serious process failure.
- The cause and consequence of the event are classified in accordance with a set of standard codes.
- If personnel are identified as a cause of the event a "Human Factors Analysis" form is completed.
- The probability of recurrence.
- Recommendations.
- Follow-up actions required.

Depersonalized SERs were reviewed as a possible source of valve failure data, with the following findings.

From the data contained in an SER it is possible in the majority of cases to determine if the identified equipment has failed. It is also possible to determine if a reported loss of valve function is due to the fault of the valve or some other component. In some cases valve failures are documented in the body of a report but are not singled out as identified equipment.

It is very rare, however, to find a discussion on the failure cause or failure mechanism associated with an equipment failure. This precludes any further analysis of the failure at this level. This problem occurs because the SER reporting system is not intended to document this level of detail of equipment failures. Even if it were so intended, it is doubtful if such information could be produced within the time allowed for production of the SER.

In general, SER's were found to be only a limited source of valve failure information, and are not recommended for such data collection.

2. SER FOLLOW-UP REPORTS

SER Follow-Up Reports are written by site technical staff to further explain the circumstances surrounding a significant event, using information that was not available in time to be

included in the SER. They identify actions required to prevent a recurrence of the event.
They are written when the department manager determines that a significant event is not analyzed or documented sufficiently in the SER or when significant follow-up action is required.

These documents were reviewed as possible sources of failure data, because they have the potential of providing more information on equipment failures than is available from an SER. This potential is provided by the additional time allowed for generation of Follow-Up Reports, during which equipment failures may be analyzed and discussed in the report. For example, cause and consequence codes and device codes for the event may differ from those in the SER if subsequent investigations proved the original assignments to be wrong.

On review, however, it was found that these reports contained little or no more equipment failure data than available from the SER. In addition, as they are written on an as-needed basis, a few significant events have Follow-Up Report documentation.

It is not feasible to use SER Follow-Up Reports as an exclusive means of gathering equipment failure data.

3. SIGNIFICANT EVENT REPORT DATABASE

SERBASE is an OH database of significant event data whose purpose is to allow easy access to information on past events and to keep track of the large number of follow-up actions. It is not in itself a reporting mechanism.

Information in the database consists of data and summaries taken from Depersonalized SERs, Follow-up Reports, Human Factors Analysis Forms, and additional data necessary to monitor progress of follow-up actions. A data record is created for every Depersonalized SER within 7 days of the report being issued.

The AECB maintains a computerized summary of the SERs it receives from all the reporting utilities. This is similar to SERBASE

used by OH for its own sites. A sort of this database was considered as a possible source of failure data. It was found that the following details can be produced:

- ISN (Internal Sequence Number)
- Event ID (Identifies facility, unit, year of event and event number in year)
- Date of event
- Abstract

The database abstract contains a summary of the event and usually identifies the system affected and the equipment code of hardware involved.

When equipment codes are given, however, they are sometimes incomplete and the format varies from one entry to the next. These inconsistencies are primarily due to a lack of standardization of equipment code entries in the database source documents, the SERs. This consequently makes the database impractical to sort on equipment codes. This fact was verified by a manual search of SERs which uncovered many failed valves of interest which were not picked up by the sort.

Another problem with using this method to search for failed equipment is that the equipment identified in the database has often not failed at all. This is not a problem with the data itself but rather a misuse of the data for this purpose. The SER reporting system highlights the device code of the first or most significant equipment involved in the event. Its failure is not the criterion for selection. The abstract and often the full SER document must be consulted to determine if the identified component had failed and thereby caused the event to occur, or if the component failed as a consequence of another component failing during the event.

From the abstract it is often possible to determine the loss of function of the identified equipment but not whether the equipment itself has failed. For example, an isolation valve may

"fail to close on demand" due to stem seizure or logic failure; the cause is generally not specified. In other instances it is difficult to identify the actual failed component.

When it is clear that the identified component has failed it is usually possible to determine its failure mode, but very rarely the cause or mechanism. Thus in the majority of cases it is unclear whether the failure was age related or not. Again this problem occurs because the SER reporting system is not intended to record the analysis of equipment failures.

In conclusion, the SER database is an unsatisfactory, or at best incomplete, source of equipment failure information.

4. DEFICIENCY REPORTING SYSTEM

DRs (Deficiency Reports) or WORDs (Work Order and Report of Deficiencies) are used at all sites to do the following:

- Record equipment deficiencies
- Initiate corrective action
- Record the corrective action taken
- Provide a cross reference to other documents which provide further detail on the work done
- Provide data for reliability and maintainability studies

A work order may be raised by any member of the facility staff.

DR's were reviewed as a possible source of information on failure causes or mechanisms.

From inspection of several DRs and interviews with a number of OH site personnel, it was determined that DRs do not provide an analysis of the equipment failure . The defect description in many cases is either misleading or wrong because the person who raised the DR could record only the symptoms of the deficiency and a probable cause. In the "Action Taken" section of the DR, the reporting is usually very brief. Such comments as item

"replaced" or "repaired" are common and provide no failure analysis information.

In order to reference a DR, either its serial number or a device code must be used. It was found, however, that DR's are difficult to reference from the other failure event reporting systems. Serial numbers are usually not available, and referencing by device code is unreliable because of a lack of standardization of device code formats used on data entry.

The deficiency reporting system is designed to identify, schedule and track the work at the facility and not to record or analyze equipment deficiencies. Because of this and the difficulties in accessing reports, DR's in their present form are not considered to be a good source of equipment failure information.

5. WORK REPORTS

Work Reports are written to document the work carried out in response to deficiency reports. One or more reports may be written when equipment related problems are investigated.

Work Reports are written by the unit which performed the work and detail the steps taken to remedy the problem. They may also include details of equipment repair, replacement, and the nature of the failure. Once completed they are filed by system code numbe[illegible]d date. Work Reports are kept in the facilities [illegible]nce shops and are therefore difficult to access and [illegible]n large quantities.

Work Reports are a possible source of valve failure causes and mechanisms, but are considered too labour intensive to access, to be recommended for data collection.

6. QUARTERLY TECHNICAL REPORTS (QTR'S)

QTRs are produced by the site reliability group to allow site staff and head office staff to review nuclear generating station

performance and operational data. They are unclassified documents and have a wide internal and external distribution.

The format of the QTRs is similar for each of the three Canadian utilities operating nuclear generating stations. Each section of the QTR addresses a specific topic. The following sections are directly relevant to this study:

Review of Major Systems This section reviews significant events and the operation of the major plant systems. It discusses planned and maintenance outages, continuing equipment deficiencies and major plant modifications completed.

Reactor Safety - Reliability Assessment This section reports on the reliability of the Special Safety Systems, Standby Support Systems and Safety-Related Process Systems.

For each Special Safety System and some Standby Support Systems the following topics are specifically addressed:

- Events involving system operation
- Significant events
- Operational problems and changes
- Contributions to past unavailability
- Descriptions of Fault types 1 to 5 (Special Safety Systems) and Fault types A & B (Standby Support System).

Any component whose failure has been identified in a reliability analysis as being capable of degrading Special Safety System performance is included in the QTR if it fails. Other SSS component failures are included if the failure affects system performance.

Reporting for the remainder of the Standby Support System and Safety-Related Process Systems is done in a less formalized manner. Only system highlights are reported.

The information used to write this section of the QTR is gathered from the following sources:

- Deficiency Reports
- Work Permits
- Work Reports
- SER system
- Station Logs
- Interviews with operators when required.

QTRs were reviewed as a possible source of valve failure data and appeared promising for the following reasons:

- They address the majority of equipment failures in Special Safety Systems and not only those that cause significant events. Therefore they should increase the valve failure population size significantly.
- Fault listings are organized by system and so are easy to reference.
- Fault listings are brief and to the point and so are quick to review.
- The fault listings are prepared some time after the event and therefore have the chance to include some post-event equipment failure analysis.

By reviewing the fault listings, it is possible to determine the following in most cases:

- Fault type and date
- Whether the fault was due to equipment failure
- The device code of failed equipment
- How the failure was discovered
- What was done to remedy the fault
- What was done to verify that the fault had been cleared.

Although it is usual to identify failed equipment in QTR fault listings it is very rare that anything but the failure mode is discussed. The descriptions of fault remedies are usually confined to "replacement" or "repair" of failed components and thus no assessment is possible as to whether the failure was age related or not.

In the text section of the QTRs there are occasional accounts of continuing valve problems associated with a particular service, valve type, manufacturer, etc.. These accounts provide much of the valve failure data required for this study but such entries are infrequent.

The fourth quarter QTRs contain lifetime and annual statistical performance tables for the major components in the safety system. These tables do not discriminate between random and age related failures as they are intended for assessment of system unavailabilities. This makes the data unsuitable for use in this study.

Ontario Hydro maintains a Reactor Safety Component Failure (RSCF) database containing failure data from the QTR's for Bruce 'A', Bruce 'B' and Pickering 'B'. That database is not yet complete for the years covered by the present study (1982-1986). Although the current investigators were not offered access to the RSCF database, its use in the future could assist with the task of failure data compilation. The quality of the data would suffer from the same limitations as those described for the QTR fault table entries.

In summary, QTRs are a good means of searching for equipment in the SSS that has failed. They are not a good source for identifying the circumstance causing the failure or the repairs necessary to return the equipment to service.

7. STATION LOGS

The Station Logs are used to record the operational highlights of each unit in a facility. An entry is made in the logs every time an important activity occurs.

The unit Shift Supervisor and Control Room Operator each write their own logs and make entries independently of each other. They are currently hand written with each entry assigned a reference time or entry sequence number.

These logs are not considered to be a useful source of valve failure data because entries are based on event symptoms as seen at the time by the shift supervisor and control room operator. Conclusions cannot be drawn from this type of data since it does not contain an analysis of the true event cause.

In addition, since entries can be referenced by date only and are not on-line, many hours of searching would be required to locate each valve in this study's failure data population. Also it is possible that many of the valve failures identified in the QTRs would not be referenced in the logs. This is because SSS valve failures are commonly found by testing and the shift supervisor and control room operator on shift at the time may not consider such a failure to be worthy of note in the logs in addition to the entries called for in the test procedure.

Since QTRs are prepared from station logs as well as other documents, it is likely that any degradation of a SSS due to an equipment fault would be more fully described in a QTR fault table than in a station log.

Station logs are therefore not recommended as a source of data for this type of study.

8. IN-SERVICE REPORTS

The In-Service Report system is an OH mechanism to communicate the knowledge gained in solving a particular problem or the results of some research. These reports can be written by any staff member who has specific information that may be of use to others.

These reports were investigated as a source of detailed equipment failure analysis.

Indexes of Bruce and Pickering publications were searched, and papers with promising titles were extracted. These papers were selectively reviewed with the following findings.

Several reports include a failure analysis of relevant equipment. These papers provide the reader with sufficient information to assess age related factors for the specific components under study. Most papers however do not provide an in-depth analysis of component failures.

In general, the population of valves covered by the reports currently available is insufficient to serve as a data source for this type of study. In addition, the narrative type format of the reports reviewed makes extracting specific data difficult, rendering the reports inconvenient to use. For those reasons, data was extracted not from these reports for use in this study. With the publication of additional reports in the future however, this source could merit a more thorough review.

A listing of the reports which were found to be relevant as background information to this study appears in Appendix C.

9. COMPONENT RELIABILITY DATA FOR CANDU NUCLEAR STATIONS

This report provides a reference source of component reliability data suitable for use in reliability analyses of CANDU stations.

It is written by the Quality Engineering Department of the Design and Construction Branch at OH and is revised approximately every two years to include the latest operating experience.

Reliability data is gathered from OH operating experience at its Bruce and Pickering nuclear facilities and other external published reliability data such as NPRD (Nuclear Plant Reliability Data System) and IEEE Standard 500-1984. For each identified component the following reliability data is given where available:

- Failure Rates - Average and 5%, 50%, and 95% one sided upper confidence levels.
- Mean Time to Repair
- Failure data population
- Total component operating time

- An error factor K. Used to perform uncertainty analysis.

The information contained in this report may be readily used in a reliability analysis but is considered unsuitable and not recommended for a study of this type due to the statistical nature of data presentation, and the absence of failure cause and failure mechanism data.

10. SUMMARY

An outline of the relationship between various equipment failure reporting systems was provided in Table C-2. The useability of the various sources reviewed above, from the standpoint of providing valve failure information is summarized in Table D-1. In summary, existing systems used to record valve failure information are not well suited to studies of the present type.

The extraction of information must be done manually for the most part, on a case by case basis, and even after combining information extracted from different sources, certain fundamental information surrounding a failure is found to be missing.

In comparison, US sources of valve failure information, developed after considerable funding and effort, provide more complete failure data and allow for easier data retrieval by means of computerized access to on-line databases. These reporting systems, and extensive funding have made possible some excellent reports such as ORNL-6170/VI.

The major US sources of valve failure information are discussed in Appendix F for comparison purposes.

E. FAILURE MODES, CAUSES, MECHANISMS AND STRESSORS

The terms "Failure Modes", "Failure Causes", "Failure Mechanisms" and "Stressors", occur repeatedly in literature addressing component malfunctions in nuclear service. Valve failure reporting systems currently in place generally supply detail as to failure mode, and perhaps causes, but are normally less fruitful with regard to information on mechanisms and stressors.

1. FAILURE MODES

A failure mode is the way in which a component fails to perform a function for which it was intended. In the case of valves, the intended functions generally include: acting upon a process fluid, within a pressure boundary, to alter its flow in some manner. The various failure modes therefore relate to a valve's inability to perform a required function in a prescribed manner.

In the various reporting systems reviewed, a large selection of failure modes are found which offer varying levels of detail about the failure incident. For purposes of this study, all reported failure modes have been assigned to one of the following seven categories:

(1) External Leakage*
(2) Internal Leakage*
(3) Fails to Open**
(4) Fails to Close***
(5) Slow to Operate
(6) Improper Operation
(7) Fails to stroke

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* May be indicated simply as 'Leakage' if location is not reported.

** Includes also "Failed Closed"

***Includes also "Failed Open"

According to the literature reviewed, the most common modes of valve failure include [7]:

(a) Failure to change position for Motor Operated Valves (MOV's)

(b) Internal or packing leakage for check, isolation, and control valves

To determine operating experience in CANDU plants, the question of the most prevalent modes of failure was addressed during interviews with OH site and Head Office personnel. The failure modes cited most frequently generally agreed with those quoted above. It was also noted that the failure of valves to change position could frequently be attributed to the failure of limit and torque switches to properly operate.

Other cited failure types included breakage of butterfly valve stems used in throttling service, and problems with position indication on testable check valves.

2. CAUSES, MECHANISMS, AND STRESSORS

In order to track, analyze, and discuss the reasons for valve failures, certain terminology must be introduced. Given a specific failure, any number of events may with some validity be considered a "cause". Consider the following example:

Modes of failure	->	External Leakage
i) Cause of Leakage	->	Degraded packing
ii) Cause of Degradation	->	Mechanical Wear
iii) Cause of Wear	->	Excessive Friction
iv) Cause of Friction	->	Overtightening of packing
v) Cause of Overtightening	->	Use of "cheater" bar on bolts

Any of the above "causes" may be of interest, thus for purposes of analysis, the introduction of a primary cause is warranted.

2.1 Cause of Failure

The direct cause of failure, or the primary cause, generally identifies the area or component of the valve which is not functioning as it should, and thus is causing the failure effect.

In the above example, the cause of failure is the degraded packing. The secondary causes in themselves will not produce the failure effect. For example, overtightening of the packing does not initially cause a failure. Other examples of primary causes might include a damaged seat or plug, a leaking gasket, or a cracked valve body.

Unless otherwise noted, in this study the Failure Cause shall refer to the primary cause.

2.2 Mechanisms

Aging of a valve is caused by the continual time or cycle dependent degradation of its component parts. For an aging related malfunction, the cause of failure is the result of one or more degrading mechanisms. In the previous example the degrading mechanism is wear.

The possible degrading mechanisms considered for this study include the following:

i) Corrosion (general, pitting, crevice, etc.)
ii) Stress corrosion cracking
iii) Erosion
iv) Creep
v) Fatigue (surface, general)
vi) Mechanical Wear
vii) Embrittlement (thermal, hydrogen, irradiation)

All of these processes if left unchecked could in time lead to the degradation of component parts, sufficient to cause a valve to malfunction.

2.3 Stressors

The external agent that induces or activates the degradation mechanism is referred to as a stressor. In our example the stressor is a dynamic mechanical stressor, namely friction. Other examples of mechanical stressors might include static pressure leading to creep, or a water-hammer pressure transient leading to the mechanism of fatigue.

In general, stressors may be assigned to one of the following categories:

i) Mechanical
ii) Electrical
iii) Chemical
iv) Thermal
v) Radiation
vi) Environmental

These stressors may naturally be associated with the design conditions of the valve, the process fluid, the surrounding atmosphere, or may inadvertently result from human input or accident. The valve components most likely to be affected by various stressors are summarized in Table E-1. It is not possible based on the failure and design data information collected during this study to identify with any certainty the stressors responsible for the various failures observed.

2.4 Contributing Factors

The factors which contribute to the primary cause of failure may best be grouped into a category called Contributing Factors. In our example the packing being too tightly compressed against the stem certainly contributed to the ultimate failure of the valve. In a like manner, torquing the bolts using a cheater bar contributed to the failure, as might the inexperience of the maintenance worker, or poor instructions. The number of possibilities here makes it impractical to assign categories, but information as to such contributing factors, when available in reports, is useful to retain in a database as comments.

Not all failures have the complete hierarchy of "causes" used in this example, but age-related failures generally follow fairly closely by to this pattern.

From the point of view of having information recorded and collected when failures occur, it is important for the reporter to understand the purpose of this information and how the information is to be reported. Without a clearly structured reporting format, responses as to the primary cause of failure and to likely contributing factors will be given rather arbitrarily and valuable information never recorded.

2.5 Predominant Causes

The failure causes for safety system valves reported most frequently in American studies, are: leaking of packing, seals, or gaskets, and worn plugs, disks, and seats. The associated mechanisms reported are: mechanical wear, erosion, and corrosion. Wear and erosion are principally due to mechanical stressors, the former due to friction, the latter due to cavitation. Chemical type stressors are responsible for the corrosion.

CANDU operating experience gleaned from interviews identified leaking glands, cracked bellows, and worn seats as problematic causes. As above, the seat wear was attributed to erosion from cavitation, whereas fatigue was felt to be causing gland and bellows damage.

In the reporting systems used for this study, causes of failure are identified only for some entries. Causes that appear with the most frequency for our failure data include problems with loose packing and ruptured diaphragms. No information regarding active mechanisms or potential stressors was included in the failure reports.

F. ANALYSIS OF REPORTED VALVE FAILURE DATA

This section presents a review of reported valve failures in Canadian and US nuclear power plants. For Ontario Hydro plants, a comprehensive database of valve failures was compiled from QTRs and SERs for the years 1982 to 1986. This database, used in conjunction with the valve population and design statistics described in Section C, provides a basis for extracting the failure data statistical and reliability summaries presented in graphical format. Trends evident from the failure data are identified and analyzed.

Valve data graphs referenced in this section can be found in Appendix A. Appendix B contains a printout of the valve database, including the failure data in Part II of that appendix.

1. VALVE FAILURE POPULATION DATABASE

The failure data portion of the valve database (Part II of Appendix B) contains data compiled for each failure recorded in the valve population database (Part I of Appendix B). Records in the failure database provide the following information, when known, for each valve failure:

- Source of Information i.e. recording system from which data was extracted. Failure events which were recorded in both SERs and QTRs are listed as being sourced from SERs.
- Failure Discovery date
- Location of valve by site, station and unit
- Valve USI, Component Code and System
- Valve Function and Type
- Discovery Method
- Failure Mode
- Actuator Type
- Failure Cause

2. ANALYSIS OF ONTARIO HYDRO FAILURE STATISTICS

The total number of failures recorded for the valves identified in the population database during the years of interest is 145. This includes 7 failures at Pickering 'A', 13 at Pickering 'B' and 110 and 15 at Bruce 'A' and 'B' respectively.

Basic statistics on the distribution of failures for each heading in the valve failure database were presented in Chapter C, section 3.3 as well as graphically in Figures A-2-1 through A-2-9 in Appendix A.

3. VALVE FAILURE RATES

In order to normalize the valve failure statistics and examine the data for trends, a series of graphs were produced to indicate failure rates per valve operating year. These results are presented in the third, fourth, and fifth series of graphs in Appendix A.

i) Failure Rate by Year (Appendix A Series III)
ii) Failure Rate by Age (Appendix A Series IV)
iii) Average Failure Rate (Appendix A Series V)

Failure rate information are calculated for those sites and systems for which failures were compiled, and for which total population statistics are available. This includes ECI, Containment, and SDS2 systems at Pickering and Bruce sites. Point Lepreau and Gentilly 2 sites are excluded for lack of failure information.

Several graphs were plotted against the following parameters:

i) Sites
ii) Systems
iii) Valve Functions
iv) Valve Types
v) Actuator Types

The following sections examine the results and offer interpretations for apparent trends.

3.1 Failure Rate by Year

Figures A-3-1 to A-3-5: The total combined failure rate for Pickering and Bruce sites is shown in Figure A-3-1, along with the individual units, and the total number of units, which were in service for each year. Rather than a steady increase in failure rate by year, as might be expected if age-related failures were a significant factor, there is a drop in failure rate from 1982 to 1984 with a slight increase in 1985 and 1986. This appears to be the result of newer units being brought on stream, after 1982 which experienced lower failure rates than the older units. This is supported by a review of the failure rates shown in Figures A-3-2 to A-3-5.

Note also that there appears to be a definite downward trend at Pickering B after its first year of operation, even though new units were being brought on stream in each of its first few years. This trend would be expected since the newer units become a smaller fraction of the total population. The trend could also be attributed to the experience gained in commissioning prior units.

3.2 Failure Rate by Age

The failure rate for this series of graphs is defined as the total number of reported failures for units at a specific age, divided by the total number of valves in service in the units at this age.

Figure A-4-1: In this figure valve failure rates are shown as a function of the age of the units in which they operate.

The variance in the failure rate from year to year tends to obscure any aging trends. The fact that the failure population for several years is based on only 2 units in service may account for a portion of the variance.

There is no clear trend of failure rate as a function of valve age.

The reader is cautioned however in drawing conclusions from the limited data available at this time.

Figures A-4-2 to A-4-4: These figures indicate a trend toward increased failure rate with age, for check valves, and isolating valves. In Figure A-4-3 a spike exists for units fifteen years of age. It should be noted that although there were only two isolating valve failures reported in the 15th year of operation, there were only 17 isolating valves contributing data to this age group, and thus the failure rate shown is high. One additional (or fewer) failure would make a large difference to the reported failure rate.

In Figure A-4-4 the spike at four years is attributed to a rash of failures of a pressure regulating valve 31760-PRV7 which contributed over 20 reported failures at Bruce A units 3 and 4 in their fourth year of operation. The actual failure rate, although high, is also exaggerated by the fact that only two units contributed data to this age group.

Figures A-4-5 to A-4-8: The failure rate trend for all actuator type in Figures A-4-5 is distorted at year four again, because of the large number of reported failures for PRV7. In Figure A-4-6 for air operated valves there seems to be a trend to increasing failure rate with age, however there are very few recorded failures for valves from 10 to 15 years. There is no evidence of increased failure rate due to aging for MOV's shown in Figure A-4-7.

Many of the failure entries for MOV's result from uncalibrated or improperly set-up limit and torque switches. This situation possibly improved with time as experience was gained in this area.

3.3 Average Failure Rate

The average failure rates for this section are defined as the total number of reported failures from 1982-86 for the parameter under consideration, divided by the total 'valve years' of operation for valves of a particular type, or at a particular location. In Figure A-5-1 it would appear that Bruce 'A' and Bruce 'B' have significantly higher recorded failure rates than the Pickering units.

Figures A-5-2 to A-5-4: All of three figures have been significantly affected by the high failure rate of 31760 PV7 discussed above. Approximately 70% of the SDS2 failures, 80% of the control valve failures, and 90% of the self actuated type of valve failures are attributable to this valve.

In each case these failures have created a disproportionate failure rate for these parameters, as is evident in the respective graphs.

4. US NUCLEAR VALVE OPERATING EXPERIENCE

This section draws some parallels between the Canadian and U.S. experience. Where information is reported and compiled differently in the two countries, direct comparison between the respective trends cannot be made.

There are several US databases which contain operating experience for equipment in US nuclear power plants. The information presented below is based on a survey of reports produced using one or more of the following databases:

- Licensee Event Report (LER) File
- Nuclear Plant Reliability Data System (NPRDS)
- In-Plant Reliability Data System (IPRDS)
- Nuclear Power Experience (NPE)

4.1 Motor Operated Valve Failures [8]

4.1.1 Valves

Containment isolation valves contribute over one third of the reported valve failures. Valves in this service fail predominantly because they do not pass routine leakage testing. The cause is usually foreign material or wear on the valve seat. Other valves such as check, control and drain valves total slightly over half of all failed valves. The majority of failures for all types of valves are either internal leakage or packing leakage.

In Canada, SDS2 accounted for most failures, followed by ECI and Containment. However, a similar trend to that in the US was experienced with regard to the predominance of leakage based valve failures.

4.1.2 Operators

The most commonly reported failure mode of motor-operated valves is failure to stroke on demand. The predominant cause of this failure mode is misadjustment or failure of a torque or limit switch, while the second most common cause is motor failure. The reported root causes of age-related failures are numerous and often combine with each other to cause the failure. They include improper maintenance and trouble-shooting, misapplication, inadequate engineering data, improper packing adjustment, too frequent operation and improper manual operation.

In Canada, improper operation accounted for most failures for all valves (29%, Figure A-2-6) followed by internal leakage.

4.2 Check Valves [9]

Valve seat leakage has been the main failure mode of check valves. Failure causes have included the accumulation of dirt and scale on the seating surfaces, foreign objects lodging between the surfaces, wear, deterioration of elastomers and insufficient pressure differential for seating.

The next most common problem is wear, scoring or fracture of valve internal components. Piping vibration has loosened fasteners which attach the obturator to the hinge pin causing the obturator to move out of position or to fall free into the valve body. A sudden start of flow through a check valve has caused the obturator to swing open and impact the stop on the valve body, resulting in the obturator moving out of alignment or breaking free of the hinge pin, or fracture of the hinge pin or its bushing on either one or both sides.

Hinge pins have corroded causing the valve to fail closed when required to open. Hinge pins have also broken due to the passage of higher than designed flows causing wider than expected swings of the obturator.

The seal between the valve seat and the valve body has failed on occasions.

Stop-check valves have been reported as failing to open when excessive pressure has been applied across the valve in its stop mode. This is probably due to the seating angles on this type of valve.

Once installed and tested, few problems have been found with check valve bodies. Only small through-wall leaks have been reported.

Small leaks through gaskets are also a rare problem.

In our Canadian survey, check valves accounted for 7.5% of all valve failures (Figure A-2-3). The predominant failure mode was internal leakage (Figure A-2-8).

4.3 Solenoid Valves [10]

The NPRDS database has a record of 206 solenoid valve failures between September 1978 and July 1984.

4.3.1 Failure to Operate

The predominant failure mode, accounting for 136 (66%) of the events, was a failure to operate. Thirty (15%) of these failures were attributed to a short circuit in the coil. Coil short circuits occur due to insulation breakdown of the coil windings. Insulation may deteriorate due to localized overheating as a result of extended coil energization. This type of service is often experienced in fail-safe poised shutdown systems. Industrial solenoid valves sometimes selected for these duties are not intended for the extended periods of actuation and fail due to misapplication. Another cause of insulation breakdown is the voltage surge experienced by a D.C. coil when it is de-energized. To reduce these surge voltage peaks, diodes are usually connected across the valve coil when the resultant increase in de-energization time is acceptable. Other reported causes of coil short circuits are unspecified aging mechanisms and contamination by such things as moisture.

Coil open circuit was the second most common reported failure cause with a count of 18 (9%). Coil open circuits are usually a result of coil short circuits which occur as described above. The localized circuit melts the conductor and opens the coil winding.

The third predominant failure cause was the presence of foreign material such as corrosion products and dirt causing the moving parts of the valve to bind.

Another 14 (8%) valves failed to operate due to worn or degraded parts. Reported deterioration includes: perforated diaphragms, broken seat discs and worn inserts. Probable causes are frequent cycling, contaminants or system pressure surges.

4.3.2 Failure To Operate As Required

The second most common failure mode was failure to operate as required with 48 (23%) events.

Sticking, binding, seizing or slow response were reported in 36 (17%) cases with no additional indication of cause.

Sticking, binding or seizing were reported in 7 (3%) cases as a result of foreign material in (2%) cases.

Worn or degraded parts were responsible for slow response in 2 (1%) cases.

4.3.3 Leakage

Leakage was the third most frequent failure mode reported with 20 (10%) events. Five (2%) cases were attributed to worn, degraded or broken parts and another 5 cases cited the presence of foreign material as the cause. The remaining 10 cases did not indicate a cause.

Caution must be used when drawing conclusions regarding predominant failure causes from the above data as 91 (44%) events were recorded with no failure cause information. It is worth noting, however, that 50% of the cases were due to either worn parts, the presence of foreign materials, or coil failures. Coil failures accounted for about half of the identified failure causes (or 28% of all solenoid valve failures).

Solenoid valves were not identified as a unique valve type in our study, but were included in the population of control valves. Control valves as a group accounted for 50% of reported valve failures in Canada (Figure A-2-3).

The predominant failure mode for control valves was improper operation followed by leakage (Figure A-2-8). This is similar to the experience reported above for solenoid valves in the U.S.

5. SUMMARY

Analysis of the limited Canadian failure data obtained during this study has identified no clear trends. There is no strong indication that valve failure rate increases with the age of the unit in which the valve is installed, hence evidence of age-related failures has not been identified. Additional data must be collected however for operating years prior to 1982 and a more detailed analysis carried out before supportable conclusions can be drawn.

On the basis of the limited comparison with US reported experience, there is good agreement between the predominant failure modes for check valves and control valves (solenoid valves) in both countries.

G. FAILURE DETECTION

This section presents the inspection and testing practices identified during this study as being used by Canadian nuclear utilities to detect valve failures in SSSs. The proportion of failures found by each method is also given. No other methods of failure detection (e.g. continuous condition monitoring) were identified.

The information presented in this section is based on conversations with OH staff at the Pickering NGS facility, CNS and RMEP at OH head office; a review of In-Service Reports at the CNS library; as well as the personal experience of the authors.

1. CURRENT INSPECTION PRACTICES

The definition of the term "inspection" as used in this study is the examination of a valve, assembled or disassembled, to determine whether or not its condition meets acceptable standards, without exercising the valve. This type of failure detection can either be done off-line or on-line.

The majority of on-line valve failure discoveries are made by operators performing routine inspection activities in the area. These inspection activities take place along regular planned surveillance routes travelled by operators in accordance with an overall plant inspection scheme. Each area of the plant is inspected at a frequency determined by the potential safety and cost penalties of a failure in that area. Operators are given a procedure identifying particular items to note or record during the inspection. It is common for the operators to identify external valve leaks from flanges, stem seals, check valve pins, seal bellows and the like, by steam plumes, water droplets, flow indications in closed drain lines, or noise. Also, operators

who are familiar with the route know the regular sounds and appearance of the environment. This allows the operator to hear normally closed valves that are passing, or notice swing check counterbalance weights out of their normal position, etc..

Panel checks are also regular activities that require operators to record a number of indications on the main control room panel on a routine basis. Process conditions, equipment operating modes, handswitch positions, etc. are noted usually at the start of each shift. Valve failures are sometimes detected by inappropriate process conditions or "Discrepancy" lamps illuminated in the handswitches for motorized valves. Discrepancy lamps illuminate when the valve position selected by the handswitch is in disagreement with the valve position indicated by its position limit switches. These lamps are normally lit only when the valve is stroking to a new position selected by the handswitch.

Valve failures are also detected by annunciation systems in the main control room. These may be hardwired and/or control-computer generated depending on the facility. Alarms are generated by valve failures if the failure adversely affects critical process conditions or the failure results in an undesirable or unsafe configuration of a safety system.

Off-line valve failure discoveries are few since valves are not normally removed from service unless they have shown signs of degradation. Valves which appear service worthy are occasionally taken out of service however as part of planned maintenance schedules, condition monitoring schemes, or plant modifications etc.. The amount of inspection a valve is given at that time depends on why it was taken out of service, and past operating history of that type of valve or service. A cursory visual inspection during handling may reveal signs of cracking, wear, erosion, corrosion, loosened fasteners, scale build up, or damage to the obturator or valve seat. A light is sometimes used to check the shut-off tightness of butterfly valves by

shining the beam in one end and looking for light around the seat in the other.

A more thorough valve inspection, as required by condition monitoring for example, may reveal failures when it is disassembled for an internal visual or dimensional check. Valves not in regular service or not tested routinely may have a dormant failure. The obturator can be jammed in its seat due to overtightening by a manual operator, or the stem can be seized in its guides or packing due to inactivity, etc..

In general, the equipment selected for routine inspection and the level of inspection performed on each piece of equipment is determined by operating experience and the potential for that equipment to cause serious safety or economic penalties if it fails.

Wear debris analysis is also used to inspect the condition of MOV actuators. Oil samples are taken from the gearbox of some valves on a regular basis and sent to the OH Research Laboratory (OHRL). OHRL assesses the wearing of the operator by an analysis of the metallic particles in the sample.

2. SUCCESS OF CURRENT INSPECTION PRACTICES

Of the valve failures considered during this study 29% are known to have been discovered by current inspection practices. (Refer also to note under success of current Testing Practices).

3. PRESENT TESTING PRACTICES

The term "testing" was considered by this study as the action of exercising or applying force to a valve or one of its components and comparing the resultant measured performance against predetermined acceptable standards.

Regular testing in Canadian nuclear generating facilities is performed in response to assumptions made in reliability analyses, manufacturer's recommendations, and previous operating experience. The scheduling, execution, and success of availability tests of SSS components are carefully monitored. Routine testing carried out in response to manufacturers' recommendations or to experience with equipment operating difficulties is scheduled on a lower priority basis and is usually scheduled subject to manpower availability.

All Canadian nuclear generating facilities either now use or are converting to a computerized system for scheduling routine testing. In addition, computers are being used to record the performance of the SSS availability testing program and to produce the year-end testing statistics for the fourth quarter QTRs.

Routine testing procedures are used to monitor the following types of valve performance parameters:

- Stroke time
- Internal leakage
- Smooth operation-visual check
- Operation of control switches
- Operation of position annunciation
- Correct response to control demands

The test procedures used for routine SSS availability testing are also used for troubleshooting problems that occur during normal operation. This minimizes the possibility of rendering the system inoperable due to ad-hoc system re-configurations, and produces test results comparable to previously collected data. Radiography is also used in troubleshooting to determine the true position of a valve obturator in the event that its position indication instrumentation is believed to be in error.

4. SUCCESS OF PRESENT TESTING PRACTICES

Of the valve failures considered during this study 29% are known to have been discovered by current testing practices. Coincidentally this is the same fraction as for current inspection practices. These percentages may be misleading however since the method of discovery for the remaining 42% of failed valves was not documented.

H. FAILURE PREVENTION AND CONDITION MONITORING

This section addresses three fundamentally different approaches to failure prevention, namely: Maintenance, Statistical Analysis Systems, and Condition Monitoring.

The Maintenance part of this section describes the valve maintenance practices of Canadian nuclear utilities as identified during this study. The information is based on conversations with OH staff at the Pickering NGS facility, CNS and RMEP at OH head office; a review of In-Service Reports at the CNS library; and the personal experience of the authors.

The Statistical Analysis Systems part outlines some of the analytical techniques that can and are being used to prevent valve failures.

The Condition Monitoring part discusses the operational mechanics of condition monitoring and some of the techniques available to determine component life. Current condition monitoring practices are also discussed.

1. MAINTENANCE

Preventive maintenance is the action taken to preserve equipment in good order. Through the use of a proper maintenance program, the effect of time dependent deterioration on equipment may be reduced.

Preventive maintenance action is generally scheduled and carried out by the mechanical maintenance department in Canadian nuclear generating facilities. What action is taken and how often varies from one valve to the next. Planned maintenance schedules for each valve usually begin with manufacturers' recommendations, warranty and regulatory requirements, or are generated in response to problems discovered during operation.

Any member of a facility's staff can propose maintenance action. Once the proposal is received by the maintenance department, it is reviewed before acceptance, with input from the site's technical staff and/or the valve manufacturer as required. Most PMSs (Planned Maintenance System) are scheduled and monitored by computerized systems that allow plant personnel outside the mechanical maintenance department to readily enquire about the maintenance history of equipment in the system.

To make maintenance actions consistent and timely, each task is usually carried out in accordance with a written procedure. If the procedure is difficult or has to be carried out in an environment hazardous to the maintainer, the maintenance time must be kept as short as possible. In this situation, a spare valve may be kept in the maintenance shop for training personnel before they are sent out into the field. For especially critical procedures or hazardous environments, the maintenance action in the field may be reduced to the replacement of a complete assembly. The removed assembly would then be refurbished under favourable conditions, maybe using special equipment, in the maintenance shop and stored for installation during the next similar maintenance activity. MOV actuator or switch assemblies are sometimes maintained in this way because the control switches need to be set accurately to ensure correct valve operation.

Typical PMS actions include:

- Replacement of control switches, diaphragms, actuator assemblies, lubricating oil, and seals.
- Lubricating valve stem and switch assemblies
- Tightening valve packing and fasteners
- Setting up control and position indicating switches
- Checking for hardening of lubrication due to high temperature and/or radiation levels.

A conversion to live loading for valve stem seals is reducing the need for regular packing tightening. Live loading uses the energy stored in a spring to maintain the pressure on the stem seal and not the elasticity of the packing material itself.

2. STATISTICAL ANALYSIS SYSTEMS

2.1 Trending of Past Component Performance

It is current practice for the Canadian utilities operating nuclear power generating plants to gather failure data of the components in the SSSs. This data is presented to the AECB once a year in the fourth quarter QTRs to satisfy licensing reporting commitments and to compare against component performance targets used in constant failure rate reliability models. The utilities compare the failure rates assumed in the reliability models with actual component failure rates, lifetime experience, and generic failure rate data, on a continuing basis to determine deteriorating performance trends before serious SSS problems occur.

In 1978, this type of trending analysis identified the main cause of the Bruce A ECI system failing to meet its availability target as an age-related problem with MOV isolation valve limit switches. The grease used to lubricate those components was hardening due to temperature and radiation stressors which prevented the limit switches, and consequently the valves, from operating. A change in the type of grease and improved ventilation which resulted in a lower ambient vault temperature, greatly reduced occurrences of this problem.

2.2 Phenomenological Basis for the Linear Aging Model

The US NRC's Nuclear Plant Aging Research (NPAR) Program [11] is conducting a project called Risk Evaluation of Aging Phenomena (REAP). One of the aims of the project is to develop a procedure which utilizes the linear aging model and its extensions to quantify the risk effects of aging.

Based on its phenomenological development, the linear aging model can be used to model aging mechanisms whose effects are cumulative and so cause a continuous increase in failure rate. In its basic form, this model assumes the cumulative effect of each damaging event to be independent of past accumulated damage or change. Examples of independent aging processes are linear wear and linear material build up. For non-linear aging phenomena such as vibration, model extensions are also available.

This model has been designed to allow the application of engineering information to aging mechanisms and their behaviour. This has resulted in the model being able to use incomplete and gross data for exploratory evaluations.

The linear aging model provides accuracy to within one order of magnitude. A detailed discussion on this technique, is provided in reference [12].

2.3 Calculating Surveillance Frequencies for Condition Monitoring Programs

The first step in determining a suitable surveillance frequency for a condition monitoring program is to identify the components which suffer the worst mix of stressors. This may be done for radiation, temperature, and humidity stressors by using the Arrhenius method which can assess the activation energy provided for degradation by each stressor [13].

The identified components are then removed from service and replaced with new components. The aged components are then tested for degradation effects and a new lifetime for the identified components is estimated by graphical techniques. From this information an initial surveillance period can be established for the condition monitoring program.

As information from successive tests is gathered a more accurate line of degradation can be plotted and the surveillance period can be modified accordingly. Once established, this worst case surveillance frequency can be conservatively applied to all similar components.

3. CONDITION MONITORING

Condition monitoring is an empirical surveillance technique in which the damage caused by various stressors imposed on equipment is assessed to predict the ability of the equipment to perform as required during the period following the observation. This assessment may be continuous or periodic.

In order to identify which damage precursor indicators are likely to exist, one has to consider what component parts valves are made of and what aging related stressors they are likely to encounter. All valves under consideration in this study contain mechanical components and may also contain electrical, pneumatic, and hydraulic components, depending on the type of actuator installed. Extensive work has been conducted at the Oak Ridge National Laboratory (ORNL) on what type of stressor acts on each component of a valve. Table E-1 referenced earlier is a brief summary of this work and has been compiled from very detailed information in ORNL report 6170/V1 (NUREG/CR-4234).

Degradation of valve components caused by aging stressors may be detected by the following methods:

- Visual inspection
- Stroking time
- Force required to operate valve
- Internal leakage rate
- External leaks
- Pressure differential across valve
- Temperature differential across valve
- Noise generation
- Vibration generation

- o Dimensional checks
- o Fastener tightness

Visual inspection may be used to determine valve stroking time, or to look for cracking, external leaks, corrosion, or wear of the disassembled valve components.

3.1 Motor-Operated Valve Analysis and Test System (MOVATS)

MOVATS is a portable signature-analysis device marketed by MOVATS, Inc. of Marietta, Georgia. It is designed to indicate to the user the general mechanical condition and the electrical control setup of motor-operated valves. Signatures of relative thrust, control switch actuation, and motor current, all superimposed on each other, can be interpreted by the test equipment to indicate performance degradation in the valve, operator, control circuit, or motor, prior to an actual failure.

This system gathers, stores, analyses, and provides hard copies of the following valve operating parameters.

- Axial motion of the worm gear
- Actuation points of the control systems' limit and torque switches
- Dynamic motor current

The above signatures are collected while the valve is cycled under ambient conditions. The instrumentation package used by this process to gather these signatures is described in Appendix "D", for the information of those who may wish to investigate the possibility of using similar systems in monitoring other valve types.

Using the MOVATS system enables two types of valve problems to be determined. First, incorrect adjustments and other abnormalities can be detected which, if left uncorrected, could lead to component degradation. Second, component degradation itself can be identified and measured.

Table H-1 gives examples of the abnormalities that can be detected by each measured parameter.

Field Experience

MOVATS signature analysis of MOVs has a proven record of detecting mechanical and electrical degradations prior to actual loss of function or significant component damage. Field tests have revealed that, even though a valve appears to be operating correctly, the signatures have shown changes in wear characteristics, packing loads, or system induced loads, that could cause a valve failure in the future.

The only criticism of its use appears to be its lack of convenience. Partial disassembly of the valve operator is required to mount the TMD, and control wiring must be disturbed to connect a multicoil transformer.

3.2 Motor Current Analysis of Motor Operated Valves

This technique is used in part by the MOVATS system described previously. The full potential of motor current analysis is not pursued by MOVATS however because of the wealth of information it has available from its stem thrust data collection. This method could provide good valve degradation diagnostics on its own however with the advantage of being convenient to use.

Research at ORNL has shown that the motor current signature of an MOV contains four levels of information:

- Mean value over a valve stroke
- Gross variations during a valve stroke
- Transients
- Frequency spectrum of periodic variations.

By analyzing all four levels of information it is expected that many types of age-related degradation of MOVs can be detected and trended.

To measure the motor current signature, a clamp-on ammeter is used with an analog output. This device is placed around one of the current carrying conductors of the MOV supply cable. It may be placed in any position between the MOV control center and the motor. No interruption of the supply or control wiring is necessary which means the MOV on test is never inoperative.

Details of the technique are discussed in Appendix E.

3.3 Ultrasonic Noise Monitoring [14][15]

Most operating equipment emits audible sounds but it is the ultrasonic emission that is most helpful in determining degradation before a serious failure occurs. Many times a valve failure is detected by chance as nearby maintenance personnel report the valve was heard "passing".

The primary use for ultrasonic noise measurement in valve condition monitoring is the ability to detect and locate small leaks on-line before the aging mechanism causes the leak to become unacceptable. Small leaks of gas or liquid are detectable because the resulting fluid turbulence generates ultrasonic noise signals.

Ultrasonic signals are sound vibrations above the frequency range of human hearing. The average ear can discern sounds up to 16 or 18 kHz, although some people can hear sounds up to 21 kHz. Due to their short wavelength, ultrasonic waves are easily attenuated, thus ultrasonic emissions from a valve leak are strongest at the leak point and so faults are easily located. In addition, since there is usually an abundance of low frequency audible noise from pumps and fans etc., at a generating station, operating detection equipment in the ultrasonic range eliminates much background noise in the signal.

Hand held ultrasonic detection equipment is readily available and costs around $5,000. When used for detecting valve leaks, a stethoscope attachment that allows the transducer to be placed in

contact with the valve body can be fitted. This eliminates most background ultrasonic noise from the signal. This technique is currently used in the oil and gas industry but no evidence of its use was found in the Canadian nuclear industry.

The output of the ultrasonic transducer is passed through a heterodyne (beat frequency) amplifier which converts the signal into the audible range. This method allows the noise to be heard through a headset while preserving the original waveform information. The amplifier output can also be displayed on an analog meter to allow the magnitude of the signal to be recorded. Models are available that allow the signal to be displayed in real time, time averaged, and logarithmic modes as well as providing chart recorder outputs. In addition, some models allow the detection frequency to be selected, from 20 kHz to 100 kHz is typical, to allow the equipment to tune-in on the required signal and so further reduce background noise.

3.4 Infrared Thermography [15]

Infrared thermography has found many applications in analyzing the condition of active electrical systems, mechanical equipment and building envelopes.

All objects emit infrared radiation at a frequency that is proportional to temperature. Infrared imaging equipment can produce a grey-scale or colour picture of these emissions which shows the temperature profile of the target. Any deterioration that results in a local increase or decrease in temperature can be detected by infrared scanning. A "normal" image can be saved on a photograph or video type and used as a benchmark against which future images can be compared while images of faulted equipment can provide a record of the fault for maintenance purposes.

This technique can be used on switchgear, motors, electrical panels, pumps, bearings, heat exchangers, valves and other electro-mechanical equipment. It can be used most effectively with valves to determine the presence of leaks when the process fluid is either at a higher or lower temperature than its surroundings.

Simple, lightweight, handheld thermal viewers without temperature measurement cost between $10,000 and $25,000. More complex systems that provide a sharper image and quantitative temperature measurement cost from $25,000 to $50,000. Top level instrumentation costing up to $70,000 gives true real time temperature images and better spatial resolution.

This study obtained no evidence that this technique was being used by the Canadian nuclear industry for valve condition monitoring.

3.5 Wear Debris Analysis [15]

Analysis of wear debris is an established condition monitoring technique used to identify machine component wear, predict failures and prevent secondary damage. As wear debris has to be collected for analysis it is useful mainly for oil wetted bearing surfaces such as those found in the gearbox of an MOV. The size, shape, quantity, colour and composition of the particles can indicate the type of wear occurring in the wetted surfaces.

Periodic analysis of oil samples taken in a controlled manner can identify wear trends and predict failures. Heat treatment and bichromatic lighting techniques can identify the composition of the wear debris and the conditions that led to its formation.

This technique is currently used for MOV gearboxes at Pickering 'A' N.G.S.

3.6 Acoustic Emission Monitoring

During data collection activities at OH, the use of acoustic sensors on relief valves was being assessed as a means of detecting internal leaks. The sensors would be placed on the valve discharge piping and their output would be continuously monitored electronically. If the measured noise exceeded a level that would likely be attributed to a valve passing or a valve failing to reseat after a stroke test an alarm would be raised. This technique would be especially valuable for valves located in hazardous environments if it replaced the need for field inspections by site personnel. At the time of writing, however, this scheme had not been implemented.

4. CURRENT CONDITION MONITORING PRACTICES

During this investigation, no comprehensive condition monitoring programs for SSS valves were identified in Canadian nuclear operating facilities. The notable exception was the use of the MOVATS system and debris wear analysis by maintenance staff at Pickering 'A' to determine the condition of MOVs.

No continuous condition monitoring techniques are apparently in use. One reason for this is probably that SSS valves are rarely active, while valve action is necessary for most of the failure precursor indicators to be measured or analyzed. In addition, it is not expected that satisfactorily operating SSS valves would be removed from service for condition monitoring if increased system unavailability were likely to result.

I. CONCLUSIONS

1. BACKGROUND

- Reported valve problems in pressurized nuclear systems in the US and a relatively high percentage of failures attributed to valves in Candu NPPs prompted the AECB to initiate the present study.

2. REGULATORY REQUIREMENTS, CODES, AND STANDARDS

- Based on the documents reviewed, it appears that specific requirements aimed at testing valves for purposes of detecting aging related valve malfunctions are absent.
- Specific valve testing requirements are absent from federal regulations and regulatory documents such as reactor operating licences, operating policies and principles, etc.. Those requirements which appear in licensing documents are aimed at demonstrating the operational readiness of specific safety-related systems. Where these requirements involve testing of safety related valves, the emphasis tends to be on determining component failure rates rather than the detection of aging related performance variations.
- Valves (and other equipment) failures are reported based on the severity of the failure (e.g. potential consequences of the failure). This practice satisfies the licensing requirements but does not allow a general component failure database to be established since only a partial history of equipment failures is produced and only for a subset of systems, namely safety-related systems. Furthermore, reporting requirements at this level do not produce (or require to be produced) the detailed failure information required for future analysis of equipment failures.
- New guidelines currently being drafted by the ASME Committee on Operating and Maintenance of Nuclear Power

Plant Components will emphasize On-Line monitoring systems such as acoustic and mechanical vibration testing, plus preventative maintenance tests or inspections which monitor changes in equipment behaviour from original baseline data.

3. VALVE POPULATION DATA

- Based on numerous requests and interviews, listings identifying the valves contained in the various SSSs did not appear to be available.
- A computerized database was compiled identifying all main valves in SSSs of Pickering 'A' and 'B', Bruce 'A' & 'B', Point Lepreau, and Gentilly 2 NGSs. Containment system valve population was represented through its two main subsystems, Containment Isolation and Dousing. A total of 1995 valves were identified for the SSSs at the above sites.
- The valve population was obtained primarily through operational flow sheets. Information given on the flowsheets was not consistent however, varying from site to site and from system to system at a given site.
- Population statistics were presented to indicate the quantity and/or distribution of valves by site, system, function, type, and actuator.
- Approximately half (52%) of all valves are contained in the ECC/ECI systems, 39% in SDS2, and 9% in containment isolation and dousing.
- Isolating valves are by far the most common type in all systems.
- Inspite of reviewing several different sources, it was not possible to establish the valve type for 48% of the valve in the study population or the actuator type in 24% of the cases.

4. FAILURE DATA

- The extraction of failure related information absorbed the greatest portion of available resources and produced disappointingly little of the information necessary to support a sound statistical evaluation of the results.

- This situation stems from fundamental limitations in the way, and the reasons for which, failure data is recorded and reported in Canadian NPPs. Further attempts at similar studies are likely to be hampered by the same limitations.
- All valve failures reported against the valve population were collected for the years 1982 through 1986 inclusive, for Pickering and Bruce Sites, by reviewing all QTRs and SERs for these sites for the years of interest.
- At present, whenever the information in the QTRs and SERs is incomplete, valve failure data can only be compiled by following lengthy paper chases through a multitude of documents. This must be repeated for each individual valve failure.
- A detailed review of existing sources of valve failure information was provided.
- A total of 145 failures were reported against the valve population over the period 1982 - 1986. Basic failure statistics are presented, illustrating the distribution of failures by site, system, function, type, year, mode of failure, and actuator type.
- Control valves accounted for 50% of the reported failures. The most frequent mode of failure was reported in the sources as "improper operation".
- The most frequent cause of failure is by leakage, which represented almost 50% of all cases when combining "leakage", "internal leakage", and "external leakage".

5. DESIGN DATA

- An attempt was made to consolidate all relevant design data on the valves within the study population. Valve data log sheets were issued to the various sites along with the listing of valves for which information was being sought. At this time, the sites were not equipped to supply the data because of the difficulties involved in retrieving such data and the level of effort required.
- Design manuals and operational flowsheets were the primary sources of valve design information. Design data

was not available for all systems, and information was not available for several important parameters. Information which was not available from the sources reviewed includes:

Installation and in-service date,

Service life (i.e. number of cycles, etc.),

Ambient conditions,

and Vibration conditions.

- Only a portion of the required design and operational data could be collected for the failed valves of the study population.

6. FAILURE MODES, CAUSES, MECHANISMS, AND STRESSORS

- Terminology pertaining to failure modes, causes, mechanisms, and stressors was defined.
- Certain objectives of this study which included the identification of stressors causing time-dependent degradation, failure modes and causes resulting from aging and service wear, and practical cost-effective precursor indicators, could not be completely fulfilled due to fundamental limitations in the available failure data.
- Valve failure reporting systems currently in place generally supply details as to failure modes, and in some cases failure causes, but normally do not contain information regarding possible failure mechanisms, or stressors.
- Based on interviews with OH site and Head Office personnel, the failure modes cited most frequently generally agreed with those identified in the study. CANDU operating experience identified leaking glands, cracked bellows, and worn seats as problematic failure causes. As with US experience, seat wear was attributed to erosion from cavitation, whereas fatigue was felt to be causing gland and bellows damage.

7. ANALYSIS OF REPORTED VALVE FAILURE DATA

- Failure rates (faults per valve year) were compiled from normalized data in terms of valve operating years. This approach takes into account the various distribution of valves and particularly the fact that certain units were operational for only a portion of the 1982-1986 period.
- Based on the collected data, no evidence was found of a general increase in failure rates over the period covered by this study. Caution must be exercised in drawing any strong conclusions however since newer units being brought into service during the period of interest and commissioning experience gained from previous units may have had an offsetting effect against potential aging related failures. In addition, certain years during the period of interest had relatively few units in operation, tending to make the failure rate data more sensitive to a small increase in number of failures for those years. Additional data must be collected for operating years prior to 1982 and a more detailed analysis carried out before supportable conclusions can be drawn.
- Repeated failures of one particular valve (31760PV7) at Bruce units accounted for a large portion of reported failures over the study period.
- Failure trends in the US were briefly reviewed and compared with Canadian experience. On the basis of a limited comparison with US reported experience, there appears to be good agreement between the predominant failure modes for check valves and control valves (solenoid valves) in both countries.

8. FAILURE DETECTION

- Current inspection and testing practices in Canadian NGSs were reviewed.
- All Canadian nuclear generating systems either now use or are converting to computerized systems for scheduling routine testing.

- Of the valve failures considered during this study, 29% are known to have been discovered by current testing practices. Coincidentally, this is the same fraction as for current inspection practices. However, the method of discovery for the remaining 42% of failed valves was not documented in the sources reviewed.

9. FAILURE PREVENTION

- Three different approaches to failure prevention, namely, maintenance, statistical analysis, and condition monitoring techniques were presented.
- During this investigation, no comprehensive condition monitoring programs for SSS valves were identified in Ontario nuclear generating facilities. The notable exception was the use of the MOVATS system and debris wear analysis by maintenance staff at Pickering 'A' to determine the condition of MOVs.
- No continuous condition monitoring techniques are apparently in use. One reason for this is probably that SSS valves are rarely active, while valve action is necessary for most of the failure precursor indicators to be measured or analyzed. In addition, it is not expected that satisfactorily operating SSS valves would be removed from service for condition monitoring if increased system unavailability were likely to result.

J. RECOMMENDATIONS

1. None of the equipment failure reporting systems used by Canadian operators of nuclear power plants fully document the failure mode, cause, failure mechanism, method of discovery, etc., of an equipment failure. This is due to a number of reasons. Firstly, the reporting systems currently implemented are not designed to document this type of data in a systematic manner and so do not require the analyst to record this information. In addition, at the time some of the reports are written, some of the detailed information may not be known.

In order to statistically analyze equipment failures in this type of report, accurate fault data is essential.

In order to improve the quality of data for future studies it is recommended that one of the current reporting systems be enhanced to record the following additional equipment failure information:

- Failure mode
- Failure cause
- Failure mechanism
- Length of service
- Accumulated hours of operation or cycles
- Stressors present
- Method of discovery
- Action taken to remedy the deficiency

Some of this information is available for some of the valve failures investigated from the fault descriptions reviewed in the QTRs. This is not a consistent source of good data, however, because these narratives are not written to a standard that requires details, such as all those identified above, to be included.

The U.S. LER system requires the author to record these details and although it is not considered an ideal source of valve failure data it has been a useful source of statistical information for many successful US studies of valve operating experience. It does not necessarily follow, however, that the Canadian SER/UER systems should be modified to mirror this system. LERs are revised and reissued whenever data becomes available after the initial report is written. As a rule, SERs are not revised once written and so would not be a good document in which to record equipment failure data that appears some time after the event.

Instead, it is recommended that the QTR system be revised to record this data. QTR fault records are written some time after the discovery of the failure and thus could include data from the many sources available following analysis of the fault. This additional data would not necessarily have to be published in the QTR, however, the complete information should be maintained and accessible.

It is further recommended that the recording of failure information in the modified QTR system be coded such that the analyst would be required to select each entry (e.g. failure mechanism) from a prescribed list. This would give the data a consistent structure, facilitate statistical analysis and enable future computerization of the data.

2. The extraction of valve failure information for the present study was done manually from SERs and QTRs. This method of data collection was necessary because coded on-line information from these sources was not available and the structure of the information required that additional interpretation and coding of the data be performed prior to any statistical analysis.

The adoption of recommendation #1, with an agreement by all Canadian operators of nuclear power plants to use the same coding scheme, would enable manual compilation of such data by non-technical staff.

It is recommended however that once consistently coded, the QTR information be stored in an on-line central system to enable the extraction of equipment failure information. Some Canadian sites now have or are proposing to computerize their fault record systems on an individual basis. It is recommended that unclassified copies of these separate databases be combined to form a CANDU equipment operating experience database accessible to future researchers of Canadian specific data.

3. Frequent misassignment of USI (or BSI) numbers for failed valves and inconsistent referencing practice between sites required considerable effort to correct before the failure occurences could be compiled for this study. Consideration should be given to the adoption of stricter numbering practices, aided if practical, by the tagging of valves to assist maintenance personnel.

4. It would help enormously with the task of gathering engineering data for the failed valve population in this and similar studies if a compendium of equipment engineering data was compiled and maintained in an on-line system. However, the manpower needed to create such a system is probably not available at the utilities or the AECB.

A less elaborate manual system could be implemented, however, that would enable the engineering data for any piece of equipment to be extracted if its USI were known. The relevant information for each piece of equipment is probably readily available at the site in which it is installed. This reference system would need the collaboration of all the sites to establish a consistent methodology and to compile all the data in one location.

5. There are several equipment failure databases in the US that may provide useful data for comparisons with Canadian operating experience. It is recommended that these information sources be used in a future study to identify generic problems associated with all valves in nuclear power plants.

6. It is recommended that future studies expand the time period beyond the 5 year span which was the subject of the current investigation. This would result in a beneficial increase in the equipment failure population and result in more statistically significant conclusions. It is recognized, however, that any future study will be limited by the availability of valve failure records and design data, as described in Recommendations 1, 2 and 3.

7. It is recommended that the petrochemical industry be consulted for its experience in failure detection and prevention techniques. It was not possible to investigate this area during this study.

8. A future study should be allocated a larger budget consistent with the efforts likely to be required for the retrieval and compilation of data. If possible, active participation of the sites and head offices should be secured, in particular in areas involving data collection. This approach should improve both the quantity and quality of collectable data, and likely prove more cost effective by minimizing travel expenses and applying the expertize of persons intimately familiar with the best sources and locations for specific information.

TABLE A-1

METHODOLOGY SUMMARY - PART 1

REVIEW OF REGULATIONS INFLUENCING VALVE INSPECTION AND TESTING

PURPOSE: To identify the fundamental requirements which mandate the testing of valves in CANDU NPPs, and to determine which of the information necessary to this study is likely to be available from formal inspection/test reports.

Also, to provide a basis against which actual inspection/test practices can be assessed.

MAIN TASKS:

a) Identify the regulatory documents which govern NPP operation in Canada.

b) Briefly review those documents for references to actual valve inspection/testing requirements or for references to other codes or standards associated with valve inspection/testing.

c) Review any referenced code or standard for particular valve inspection/testing requirements, identify procedural and data logging requirements.

d) Identify resulting documents or systems used by Canadian NPPs to report and store mandatory (and any voluntary) inspection/test data on valves.

e) Briefly outline analogous American requirements for comparison purposes (since many Canadian standards reference American Codes and Standards).

TABLE A-2

METHODOLOGY SUMMARY - PART 2

DATA IDENTIFICATION AND COLLECTION

PURPOSE: To define the data requirements for a valve aging and malfunction study. To identify which data may be available. To develop a practical method of collecting available data, consistent with available resources. To collect and evaluate the data.

MAIN TASKS:

a) Collect and review literature on aging-related valve malfunctions and general studies on Candu NPP valves likely to contain base data.

b) Define the specific types of data needed for an analysis of aging related valve malfunctions.

c) Identify the reporting systems, procedures and numerous documents in CANDU operations likely to contain valve failure data (this task assisted by task (d) Table A-1).

d) Identify potential sources for technical and design data relating to valves.

e) Review the structure and contents of typical documents identified in (c) and determine each one's potential value to a study of this nature.

f) Investigate additional sources for data defined in (b) above and found lacking in the documents reviewed in (e).

g) Develop a practical means of collecting the necessary valve failure data along with related design and technical data.

h) Select the sites, systems, and valve types to serve as study population, in a manner consistent with the resources available for the study.

i) Identify technical contacts within the various departments and prepare specific data requests for issue to sites.

j) Evaluate the data received from (i) and supplement with data obtained directly by the investigators' documentation reviews or interviews at nuclear sites and off-site offices.

TABLE A-3

METHODOLOGY SUMMARY - PART 3

DATA COMPILATION AND ANALYSIS

PURPOSE: To produce a database containing valve design and failure data, structured to permit various failure statistics and trend analyses to be performed. The database should be formatted to serve as a basis for subsequent studies of a like nature whether involving valves or other components.

MAIN TASKS:

a) Design a computerized database, structured to accept all relevant data identified and collected in Part 2 (refer to Table A-2 for details).

b) Seek means for automated data transfer from existing reporting systems into the database and combine with manual data entry.

c) Analyze the data to obtain:

- A definition of the valves contained in the study population.

- A record of valve failures in each system, prevalent failure modes, and other statistical information.

- An assessment of the direct causes and contributing factors to the failures.

- An assessment of whether any time dependent or service wear related degradation is suggested by the data.

- An indication of changes in failure patterns which could be attributed to differences in inspection, maintenance or test methods.

d) Present results in graphical form.

e) Produce hardcopy outputs of all data for verification and reference purposes.

TABLE A-4

METHODOLOGY SUMMARY - PART 4

REVIEW OF CURRENT INSPECTION, MAINTENANCE AND TEST PRACTICES

PURPOSE: To provide a basic assessment of the degree to which current inspection, maintenance, and test practices meet existing requirements, and to assess the effectiveness of current practice in detecting or preventing incipient failures.

MAIN TASKS:

a) Identify and briefly review inspection/test procedures related to valves.

b) Review selected inspection, maintenance, and test reports.

c) Interview operations staff at selected sites to obtain first-hand accounts of actual practice, perceived problems, and to obtain grass roots recommendations.

d) Assess, subject to a limited scope of review, current practice against requirements identified by task c) Table A-1.

e) Assess the effectiveness of current practice in detecting or preventing incipient valve failures through consideration of methods employed, records kept, and any trends suggested by the data analysis.

TABLE A-5

METHODOLOGY SUMMARY - PART 5

RECOMMENDATIONS TO IMPROVE
FAILURE DETECTION AND PREVENTION

PURPOSE: To provide information to the AECB and NPP operators which will assist in the development of improved failure detection and prevention methods.

MAIN TASKS:

a) Review failure detection and failure prevention methods in the literature.

b) Comment on applicability of these methods as a means of mitigating aging related degradation of valves in CANDU NPPs.

c) Identify shortcomings of the present study and recommend areas for future work.

d) Document all collected information in a manner which will prove useful to future studies in this area and will promote constructive review by interested parties.

TABLE C-1

VALVE POPULATION DATA

COLLECTED FROM OPERATIONAL FLOWSHEETS

SITE	SYSTEM		
	ECC	SDS2	CONT
Pickering A	√	(1)	(2)
Pickering B	√	√	(2)
Bruce A	√	√	(2)
Bruce B	√	√	(2)
Point LePreau	√	√	√
Gentilly	(3)	(3)	√

(1) System does not exist

(2) Flowsheets do not exist specifically for this system, population info. extracted from testing documentation.

(3) Valve count assumed identical to Point LePreau

TABLE C-2

OVERVIEW OF REPORTING SYSTEMS USED TO RECORD EQUIPMENT FAILURES

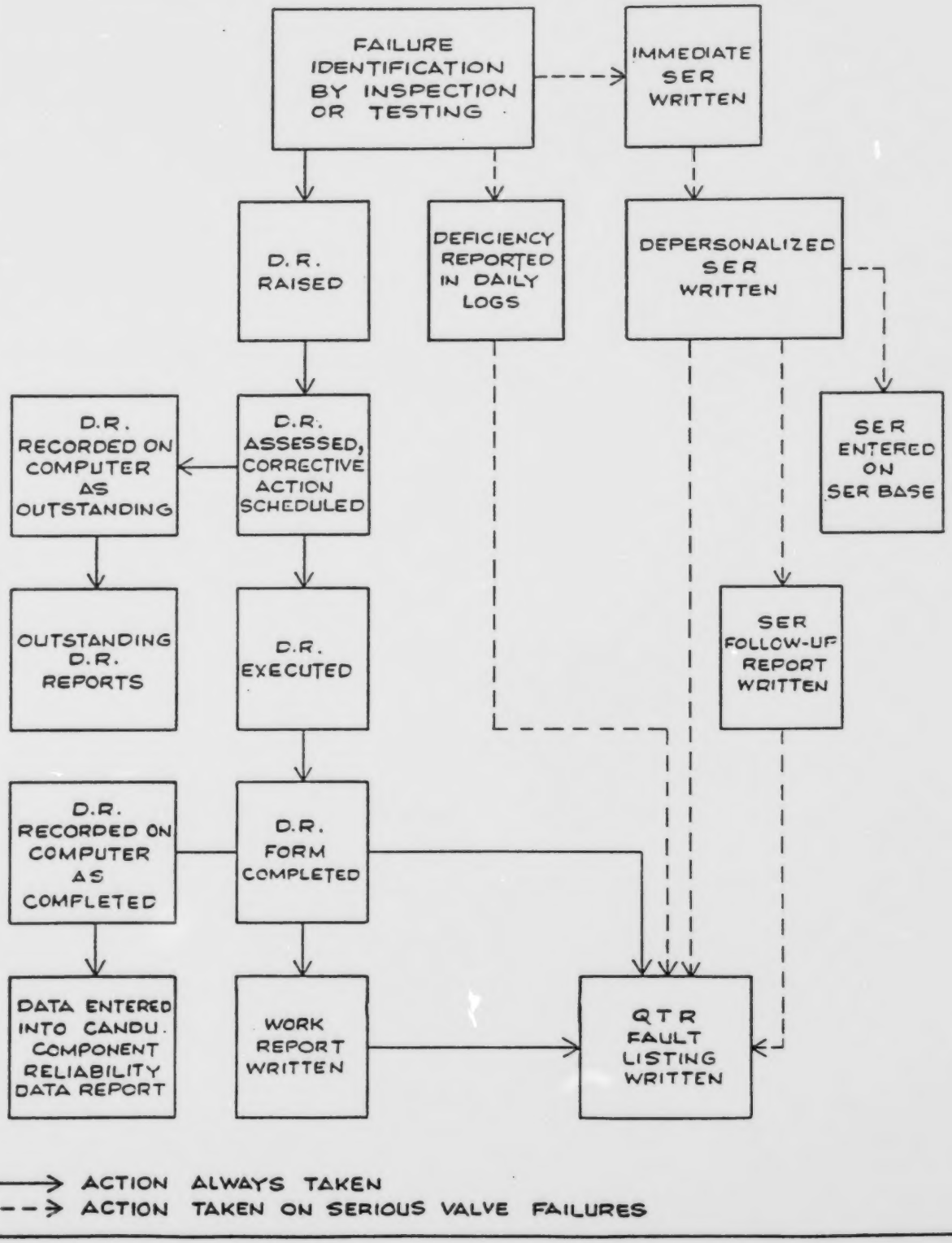
FAILURE IDENTIFICATION BY INSPECTION OR TESTING
IMMEDIATE SER WRITTEN
D.R. RAISED
DEFICIENCY REPORTED IN DAILY LOGS
DEPERSONALIZED SER WRITTEN
D.R. RECORDED ON COMPUTER AS OUTSTANDING
D.R. ASSESSED, CORRECTIVE ACTION SCHEDULED
SER ENTERED ON SER BASE
OUTSTANDING D.R. REPORTS
D.R. EXECUTED
SER FOLLOW-UP REPORT WRITTEN
D.R. RECORDED ON COMPUTER AS COMPLETED
D.R. FORM COMPLETED
DATA ENTERED INTO CANDU COMPONENT RELIABILITY DATA REPORT
WORK REPORT WRITTEN
QTR FAULT LISTING WRITTEN
ACTION ALWAYS TAKEN
ACTION TAKEN ON SERIOUS VALVE FAILURES

TABLE C-3

SPECTRUM
ENGINEERING CORP. LTD.
P.O. BOX 697, PETERBOROUGH ONTARIO K9J 7C8
Tel: (705) 743 7520 Telex: PETENG OC 062856

NUMET
ENGINEERING LTD
P.O. BOX 1776 PETERBOROUGH ONTARIO K9J 7X8
Tel: (705) 743-2700 FAX: (705) 743-3910

DATE: 87.10.22

AGING & MALFUNCTION OF VALVES

STUDY BY NUMET ENGINEERING LTD/
SPECTRUM ENGINEERING COMPANY LTD

COMMISSIONED BY THE A.E.C.B.

VALVE DATA LOG SHEET

Plant Name: _____ Unit(s): _____

System: _____ Page _____ of _____

Completed by: _____ Date: _____

ENTRY NO.	ITEM	VALVE			
1	Valve Identification				
2	Valve Type				
3	Nominal Size (in)				
4	Manufacturer				
5	Model No.				
6a	Material - Body				
6b	- Bonnet				
6c	- Yoke				
6d	- Stem				
6e	- Seat				
6f	- Obturator				
6g	- Packing				
6h	-				
6i	-				
6j	-				
7a	Actuator Type				
7b	Manufacturer				
7c	Model No.				
8	Process Fluid				
9	Fluid Temp. ^{o}F				
10	Fluid Pres. psig				
11	Differential Pres.psig				

SAMPLE ONLY

TABLE C-4

DESIGN DATA AVAILABILITY

ITEM	AVAILABILITY OF INFORMATION ON DESIGN DATA SHEETS
VALVE	ALWAYS INCLUDED
NOMINAL SIZE	ALWAYS INCLUDED
MANUFACTURER	SOMETIMES INCLUDED
MODEL NO.	SELDOM INCLUDED
MAT'L - BODY	ALWAYS INCLUDED
- BONNET	ALWAYS INCLUDED
- STEM	SELDOM INCLUDED
- SEAT	SELDOM INCLUDED
- OBTURATOR	SELDOM INCLUDED
- PACKING	SELDOM INCLUDED
ACTUATOR TYPE	ALWAYS INCLUDED
" MAN.	SELDOM INCLUDED
" MODEL NO.	SELDOM INCLUDED
PROCESS FLUID	SOMETIMES INCLUDED
FLUID TEMPERATURE	ALWAYS INCLUDED
FLUID PRESSURE	ALWAYS INCLUDED
DIFF. PRESSURE	ALWAYS INCLUDED

SPECTRUM
ENGINEERING CORP. LTD.
P.O. BOX 687, PETERBOROUGH, ONTARIO, K9J6Z6
Tel:(705)743 7530 Telex:PETENG 06 962898

NUMET
ENGINEERING LTD
P.O. BOX 1778, PETERBOROUGH, ONTARIO, K9J7X8
Tel:(705)743-2708 FAX:(706)743-3018

AGING & MALFUNCTION OF VALVES

STUDY BY NUMET ENGINEERING LTD/
SPECTRUM ENGINEERING COMPANY LTD

COMMISSIONED BY THE A.E.C.B.

VALVE DATA LOG SHEET (cont'd)

12a	Installation Date				
12b	In Service Date				
13	Service Life				
14a	Ambient Conditions - Temp °F				
14a	- Radiation				
14b	- Humidity				
14c	-				
14d	-				
14e	-				
15a	Vibration - Spec.				
15b	Vibration - Service				

SAMPLE ONLY

TABLE C-5

VALVE DESIGN INFORMATION CONTAINED IN OPERATIONAL FLOWSHEETS OF CANADIAN NGS

NGS	VALVE ID	VALVE SERVICE	VALVE TYPE	OPERATOR TYPE	NORMAL OP'G POSITION	ACTION	INSTRUMENTATION	PROCESS FLUID
Pickering	USI	Check, Relief Control Isolation		Manual Proportional Control Open/Closed				Yes
Bruce	USI	Check Relief Control Isolation	Butterfly Gate Globe Needle Ball Diaphragm Plug	Air Electric Manual	Open or Closed	Failure position for air operated valves.		Yes
Pt. Lepreau	BSI	Check Relief Control Isolation	Butterfly Gate Globe Needle Ball Diaphragm Plug	Air Electric Manual Air & Manual Electric & Manual	Open or Closed	Failure position for air operated valves.	Local and remote position indicators with associated alarm messages. Automatic operation control from control computer.	Yes
Gentilly 2*	BSI	Check Relief Control Isolation	Butterfly Globe Gate	Air Electric Manual	Open or Closed	Failure position for air operated valves.	Position limit switches	Yes

* Only one flowsheet from this facility was reviewed. It is probable that more information is available than presented here because the Systeme D'Eau D'Urgence (EWS) flowsheet reviewed likely does not contain all types of valves and operators etc.. It was assumed for the purposes of this study that at G2 SSSs were identical to those of Point Lepreau. The information available from the EWS flowsheet was as shown above.

TABLE D-1

USABILITY OF VARIOUS SOURCES FOR PROVIDING VALVE FAILURE INFORMATION

DATA	SER (1) DATA BASE	SERS (1)	SER (1) FOLLOW-UP	QTRs	DEFICIENCY REPORTING SYSTEM	WORK REPORTS	IN-SERVICE (1) REPORTS	STATION LOGS	CANDU (2) DATA BASE
Valve Failure Identification	+	o	o	x	+	x	x	+	
Valve Type				o	o		x		x
Valve Service				o	o		x		x
Valve Fluid		o	o	o	o		x		
Valve Code #		x	x	x	+	x	x	+	
Failure Mode		o	o	x	o		x		x
Failure Cause		o	o	o		o	x		
Failure Mechanism							x		
Actuator Type		o	o	o			x		
How Fault Discovered		o		x	o		x		

x usually available
o occasionally available
+ apparently available - likely misleading

1) Not available for all SSS equipment failures
2) Generic data only.

TABLE E-1

SUMMARY OF VALVE COMPONENT STRESSORS

	STRESSOR					
	Mech.	Elect.	Thermal	Chem.	Rad.	(2) Environ.
Component						
Body	X		X	X		X
Bonnet and Yoke	X		X	X		X
Fasteners	X		X	X		X
Seat	X		X	X		
Obturator	X		X	X		
Stem	X		X	X		X
Gaskets	X		X	X		X
Stem seal	X		X	X		X
Operator	X	X(1)	X	X(1)	X(1)	X

(1) depending on type of operator

(2) humidity, temperature, steam etc.

TABLE H-1

EXAMPLES OF MOV ABNORMALTIES DETECTABLE BY MOVATS SIGNATURE ANALYSIS (2)

	Stem Thrust	Control (1) Switch Actuation	Motor Current	Age Related	Non-Age Related
Bent stem	X		X	X	
Gear wear	X		X	X	
Stem wear	X			X	
Lack of Stem lubrication	X				X
Loose stem-nut Locknut	X				X
Excessive Packing Tightness	X		X		X
Improper seating	X				X
Backseating	X				X
Seating overshoot	X				X
Grease hardening	X		X	X	
Motor degradation			X	X	
Motor pinion binding			X	X	
Improperly set by-pass switch	X	X	X		X
Incorrect torque switch calibration	X	X			X

1) Incorrect adjustments or other abnormalties.

2) Source-ORNL report NUREG/CR-4380. [16]

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[15] Plant Engineering, February 26, 1987.

[16] J.L. Crowley, D.M. Eissenberg "Evaluation of the Motor-Operated Valve Analysis and Test System (MOVATS) to Detect Degradation, Incorrect Adjustments and Other Abnormalities in Motor-Operated Valves", ORNL-6226, NUREG/CR-4380.

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APPENDIX A

VALVE DATA GRAPHS

CONTENTS

LIST OF ABBREVIATIONS

SERIES I	Valve Population Statistics	- Lead Sheet
		- Figures
SERIES II	Failure Population Statistics	- Lead Sheet
		- Figures
SERIES III	Valve Fractions by Year	- Lead Sheet
		- Figures
SERIES IV	Valve Fractions by Age	- Lead Sheet
		- Figures
SERIES V	Average Fractions	- Lead Sheet
		- Figures

Abbreviations used in this Appendix

Pick A	-	Pickering "A"
Pick B	-	Pickering "B"
PtL	-	Point LePreau
Gen.	-	Gentilly
Chk.	-	Check Valve
Isol.	-	Isolating Valve
Ctrl.	-	Control Valve
PRV	-	Pressure Regulations Valve
ECC	-	Emergency Core Cooling
SDS2	-	Safety Shutdown System 2
CONT.	-	Containment System
HYD.	-	Hydraulically Actuated Valve
SELF	-	Self Actuated Valve
MAN.	-	Manually Actuated Valve
AIR	-	Air Actuated Valve
SOL.	-	Solenoid Actuated Valve
MOV	-	Motor Operated Valve
L	-	Leak
EXL	-	External Leak
INL	-	Internal Leak
FC	-	Failed Closed
FO	-	Failed Open
FTC	-	Failed to Close
FTO	-	Failed to Open
FTS	-	Failed to Stroke
SLOW	-	Slow to Operate
IMOP	-	Improper Operation

SERIES I - VALVE POPULATION STATISTICS

LEAD SHEET

DESCRIPTION:	Breakdown of valve population by actual quantities or relative distribution, for selected parameters.
SYSTEMS:	ECC, SDS2, CONT.
SITES:	Pickering A, Pickering B, Bruce A, Bruce B, Point LePreau, Gentilly
METHOD OF CALCULATION:	N/A

LIST OF FIGURES:

A-1-1	Valve Quantities by Site
A-1-2	Valve Distribution by System
A-1-3	Valve Quantities by Function
A-1-4	Valve Distriburion by Type
A-1-5	Valve Distribution by Actuator

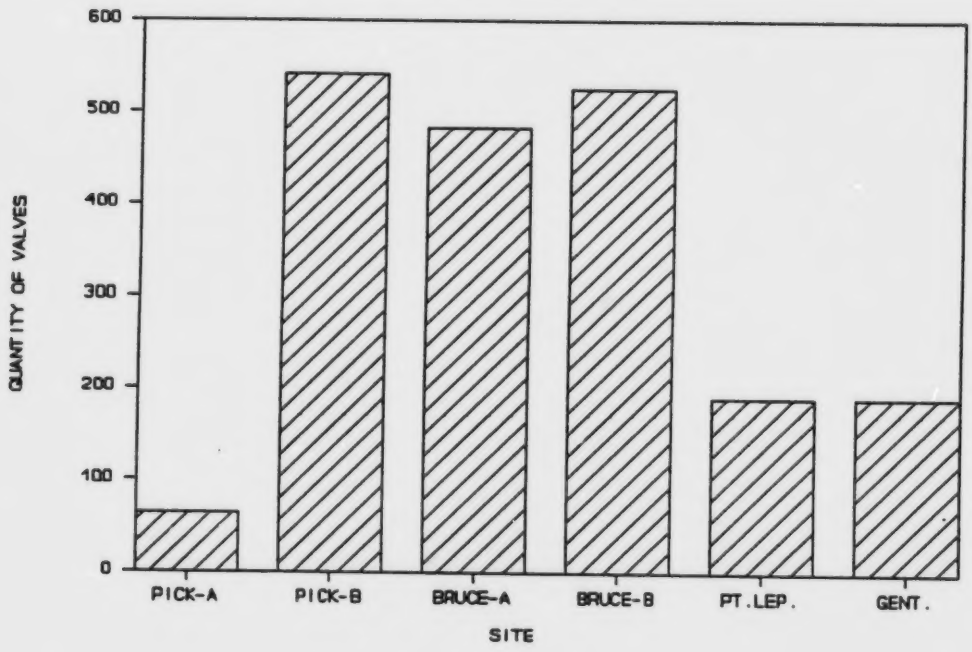


FIGURE A-1-1: VALVE QUANTITIES BY SITE

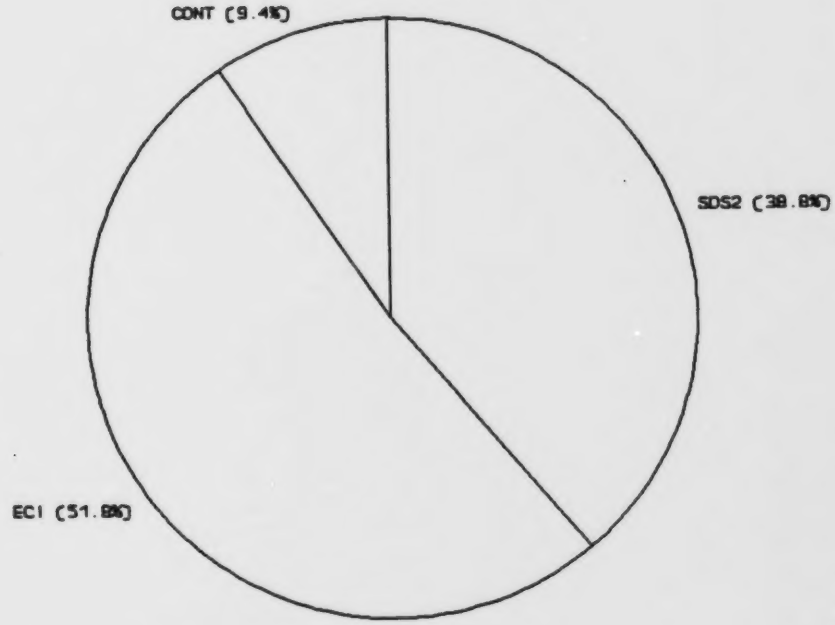


FIGURE A-1-2: VALVE DISTRIBUTION BY SYSTEM

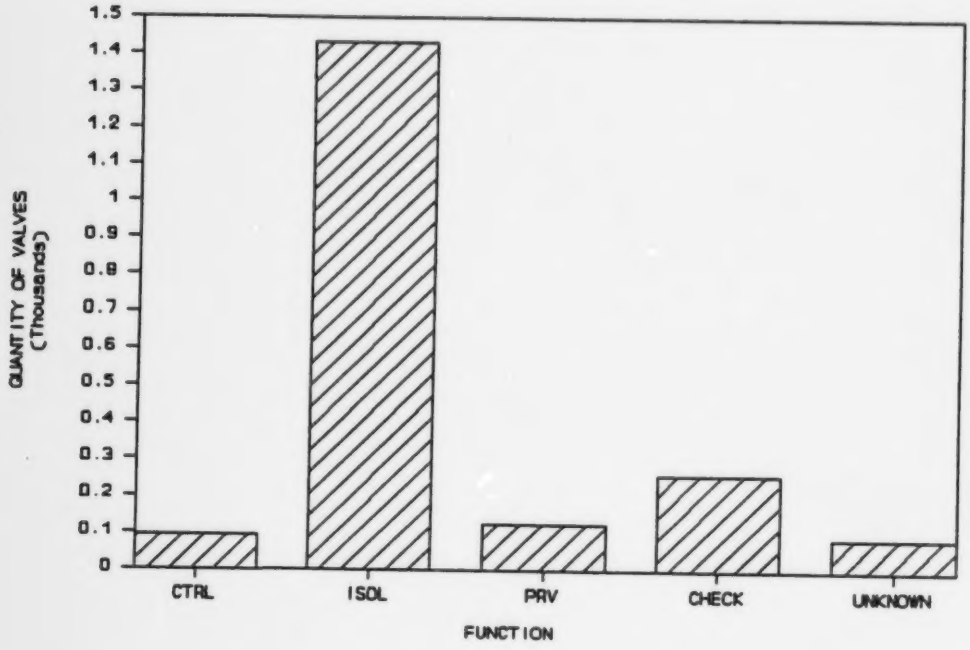
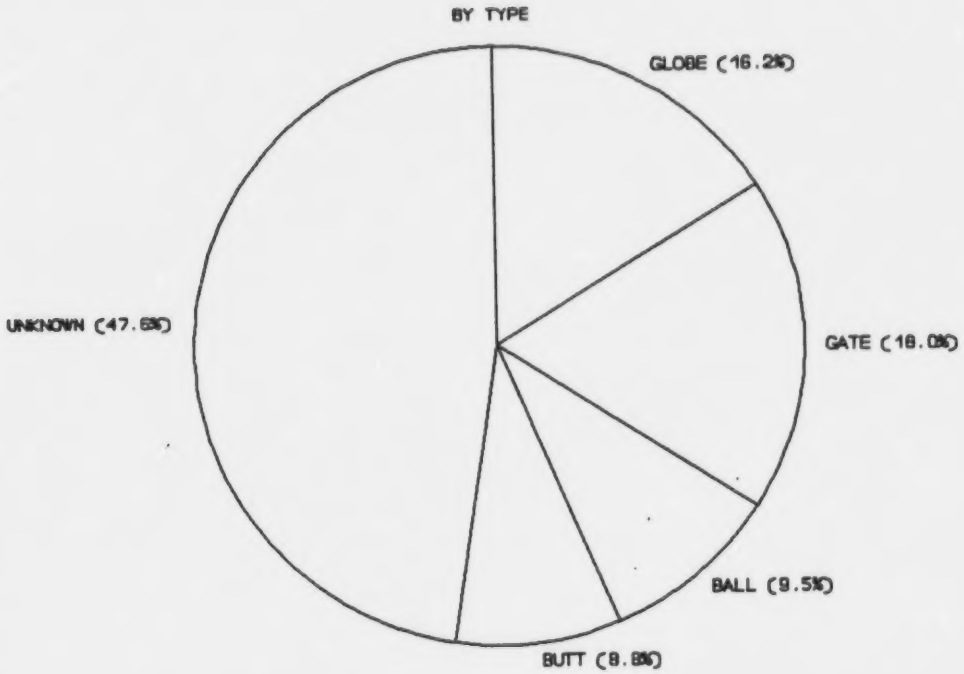


FIGURE A-1-3: VALVE QUANTITIES BY FUNCTION



A-1-4: VALVE DISTRIBUTION BY TYPE

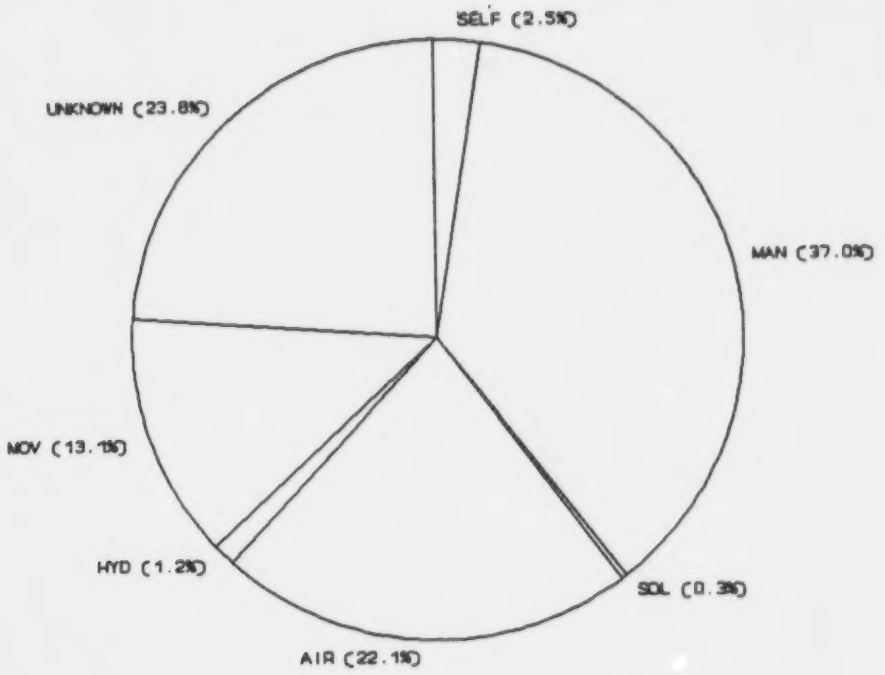


FIGURE A-1-5: VALVE DISTRIBUTION BY ACTUATOR

SERIES II - FAILURE POPULATION STATISTICS

LEAD SHEET

DESCRIPTION: Breakdown of valve population of recorded failure events by actual quantities or relative distributions.

SYSTEMS: ECC, SDS2, CONT.

SITES: Pickering A, Pickering B, Bruce A, Bruce B.

METHOD OF CALCULATION: N/A

LIST OF FIGURES:

A-2-1	Distribution of Reported Failures by Site
A-2-2	" " " " " System
A-2-3	" " " " " Function
A-2-4	" " " " " Type
A-2-5	" " " " " Year
A-2-6	" " " " " Mode
A-2-7	" " " " " Actuator
A-2-8	Quantities of Reported Failures by Function - Stacked by Mode
A-2-9	Quantities of Reported Failures by Type - Stacked by Mode

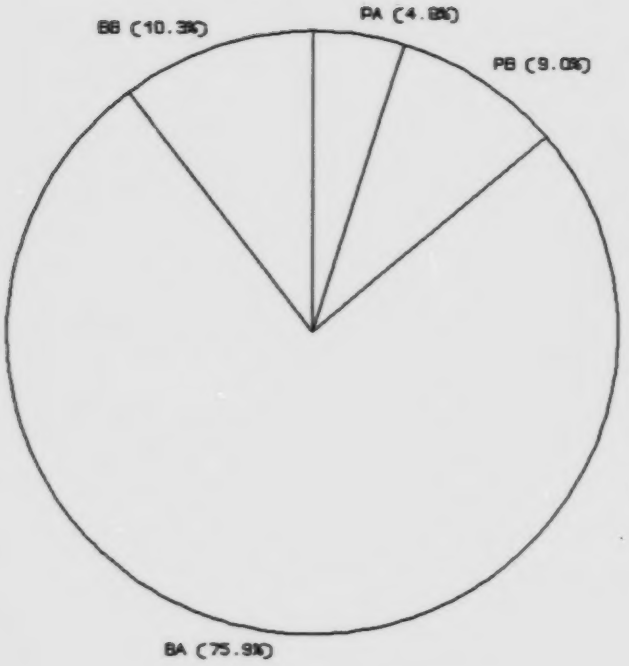


FIGURE A-2-1: DISTRIBUTION OF REPORTED FAILURES BY SITE

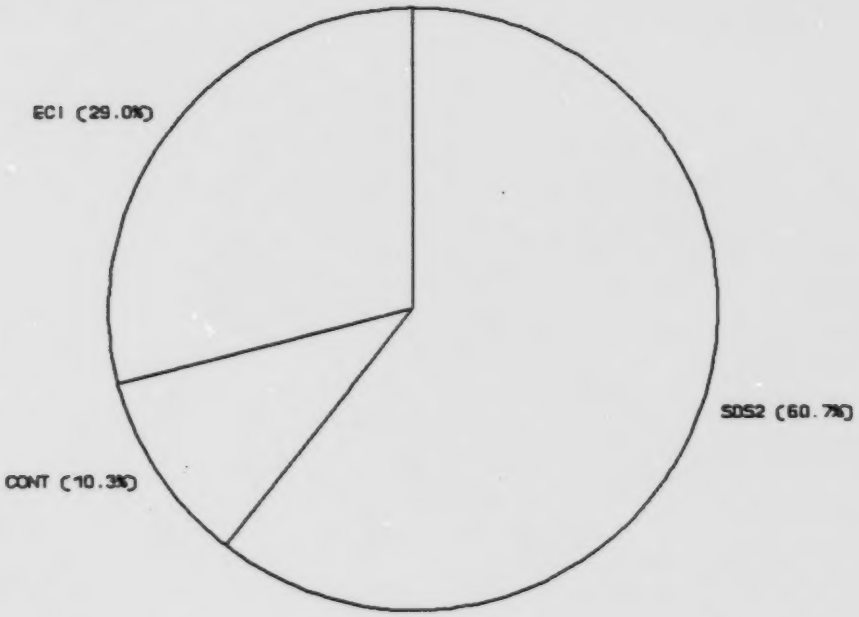


FIGURE A-2-2: DISTRIBUTION OF REPORTED FAILURES BY SYSTEM

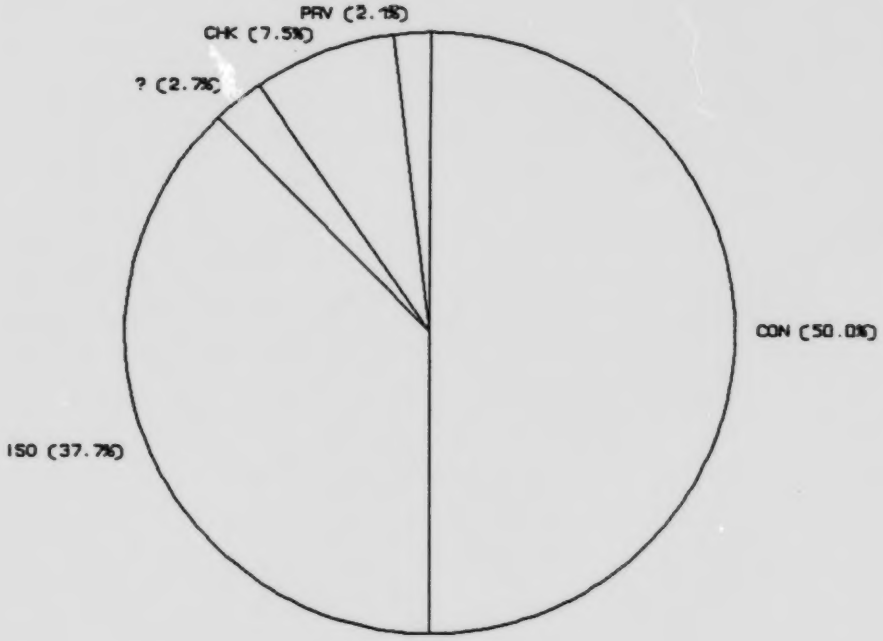


FIGURE A-2-3: DISTRIBUTION OF REPORTED FAILURES BY FUNCTION

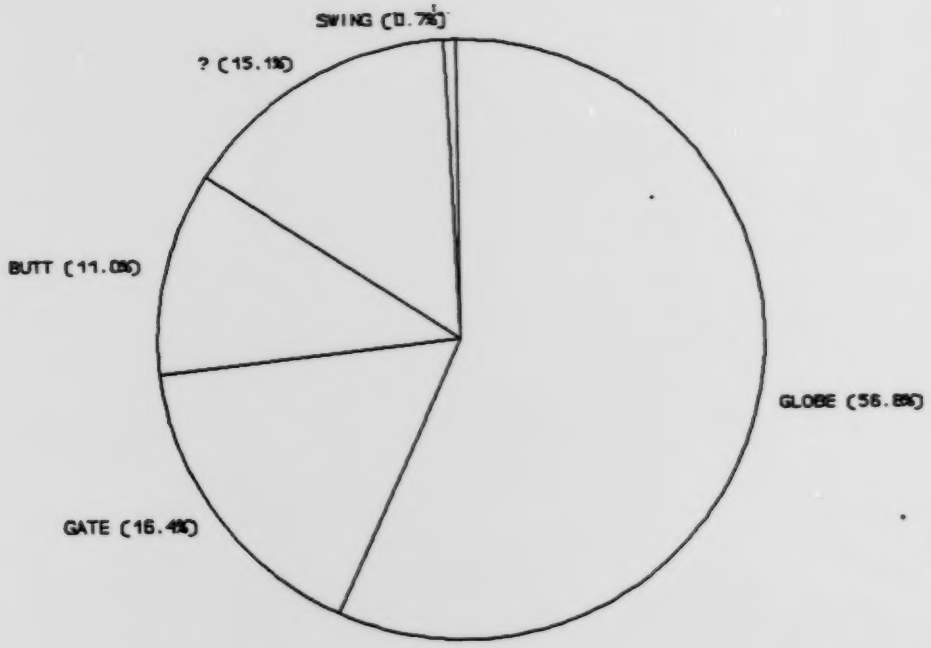


FIGURE A-2-4: DISTRIBUTION OF REPORTED FAILURES BY TYPE

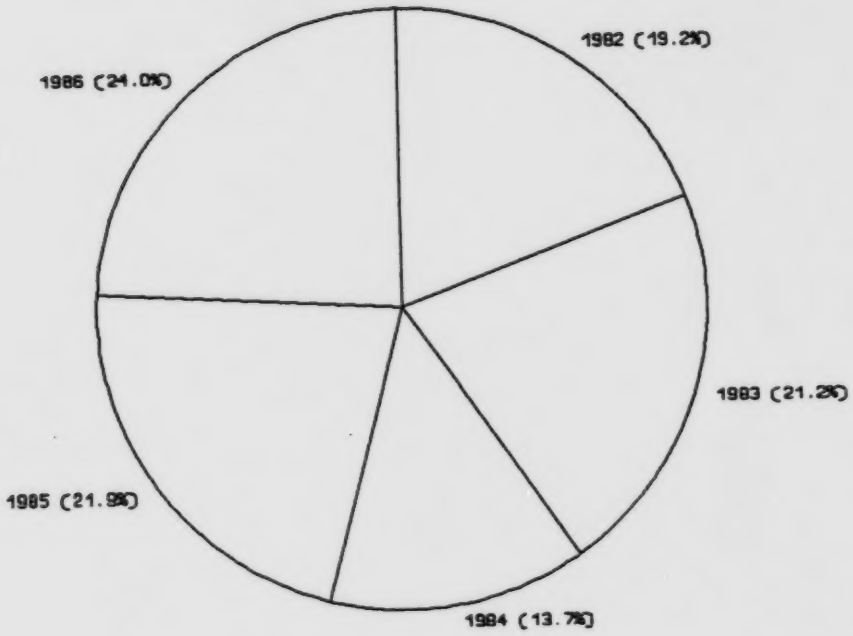


FIGURE A-2-5: DISTRIBUTION OF REPORTED FAILURES BY YEAR

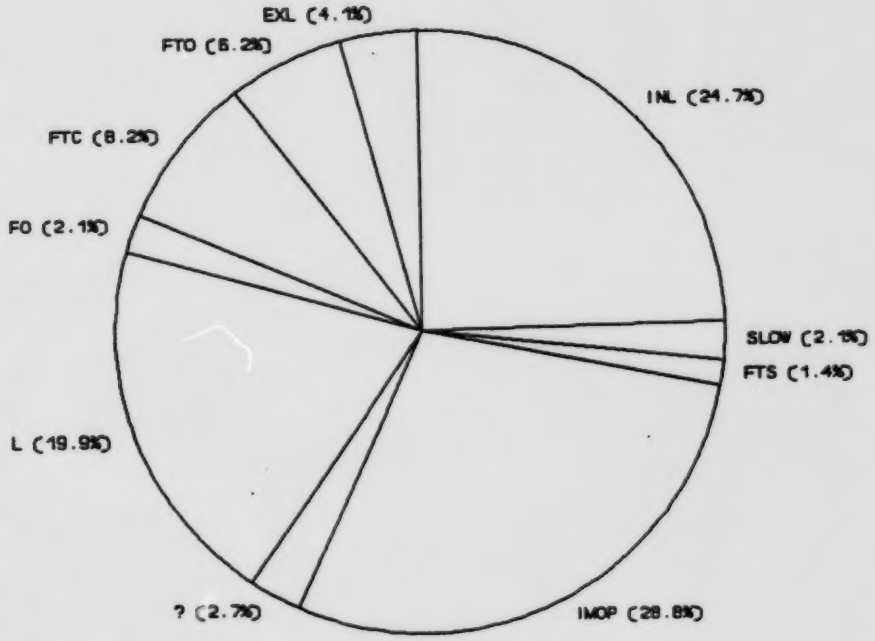


FIGURE A-2-6: DISTRIBUTION OF REPORTED FAILURES BY MODE

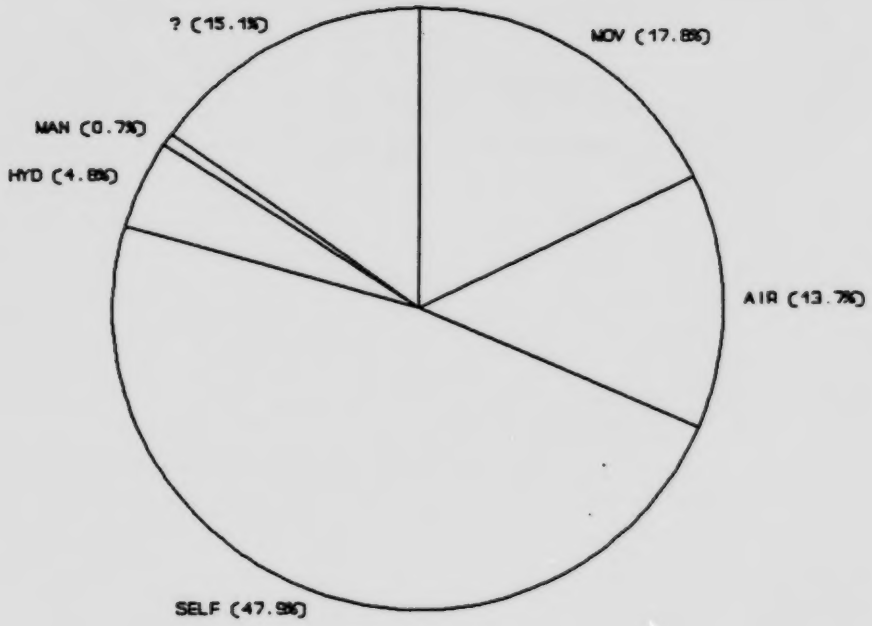


FIGURE A-2-7: DISTRIBUTION OF REPORTED FAILURES BY ACTUATOR

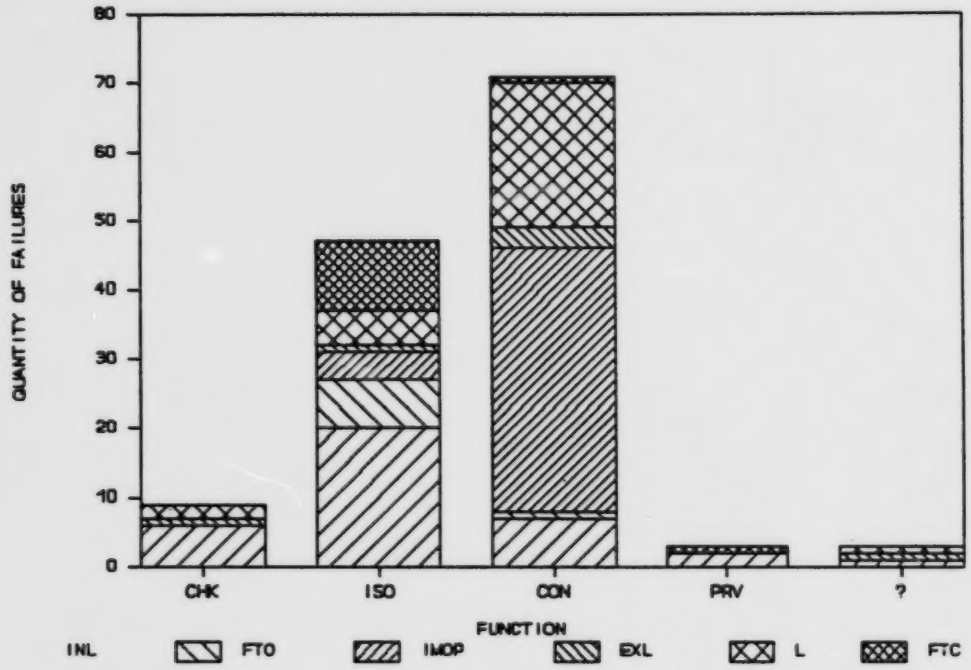
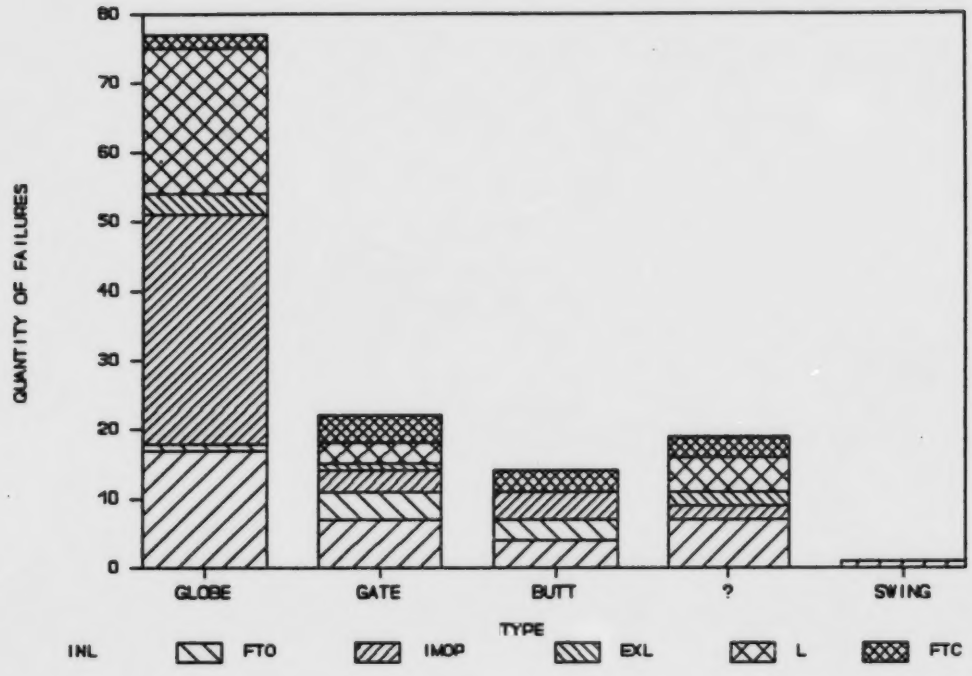


FIGURE A-2-8: QUANTITIES OF FAILURES BY FUNCTION STACKED BY MODE



A-2-9: QUANTITIES OF FAILURES BY TYPE STACKED BY MODE

SERIES III - FAILURE FRACTION BY YEAR

LEAD SHEET

DESCRIPTION: Failure fraction of valves for years 1982, 1983, 1984, 1985 and 1986.

SYSTEMS: ECC, SDS2, CONT.

SITES: Pickering A, Pickering B, Bruce A, Bruce B

METHOD OF CALCULATION:

$$\text{FAILURE FRACTION} = \frac{\text{Total quantity of reported valve failures for the site(s) or system(s) under consideration for the give year}}{\text{Total quantity of valves in service for this site(s) or system(s) for the given year.}}$$

LIST OF FIGURES:

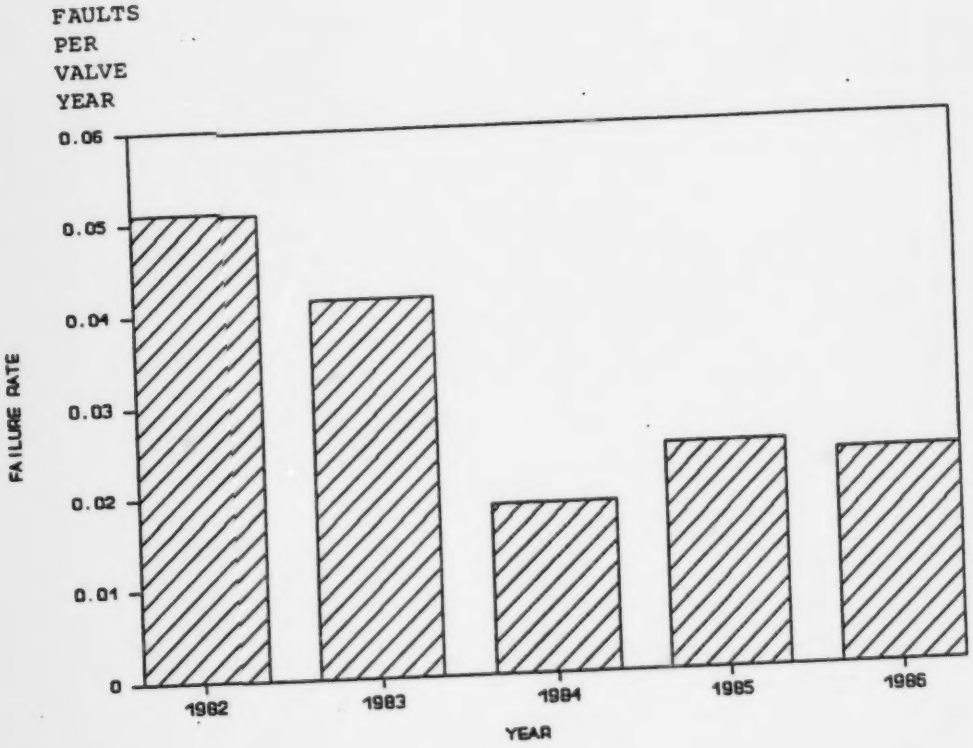
A-3-1 Failure Fraction by Year

A-3-2 " " " " - Pickering A

A-3-3 " " " " - Pickering B

A-3-4 " " " " - Bruce A

A-3-5 " " " " - Bruce B



Total Number of Units in Service During This Year	8	7	9	11	13

Units In Service

P	1	----------
	2	----------
	3	----------
	4	----------
	5	----------
	6	----------
	7	----------
	8	
B	1	----------
	2	----------
	3	----------
	4	----------
	5	----------
	6	----------
	7	
	8	

FIGURE A-3-1: FAILURE FRACTION BY YEAR
PICKERING AND BRUCE ALL UNITS

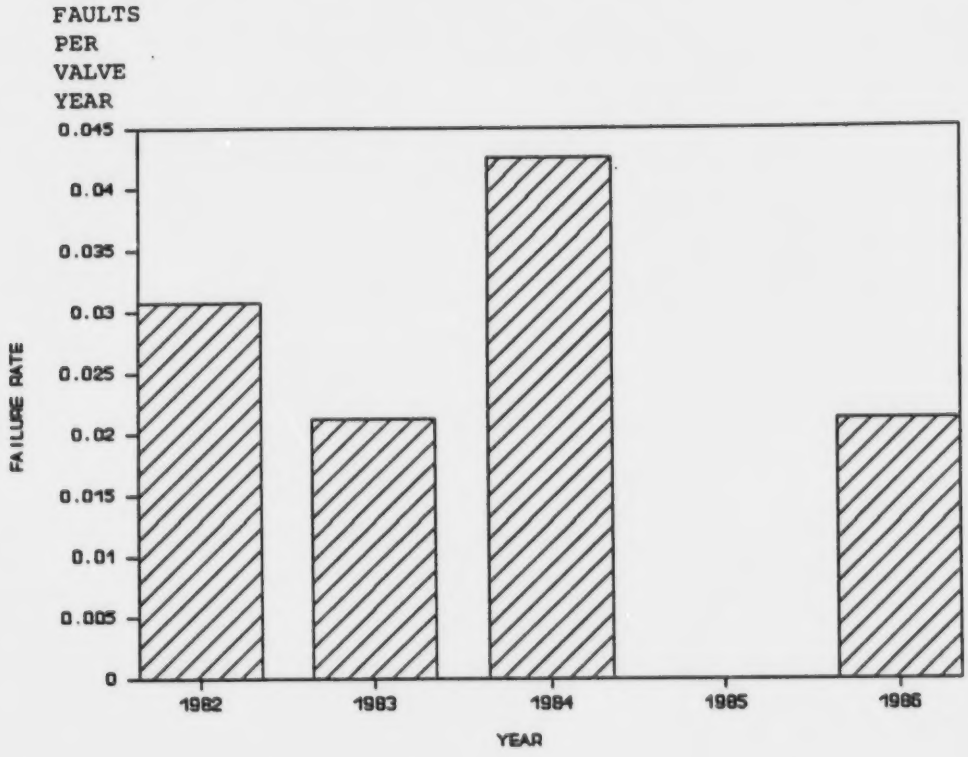


FIGURE A-3-2: FAILURE FRACTION BY YEAR
PICKERING A - ALL UNITS

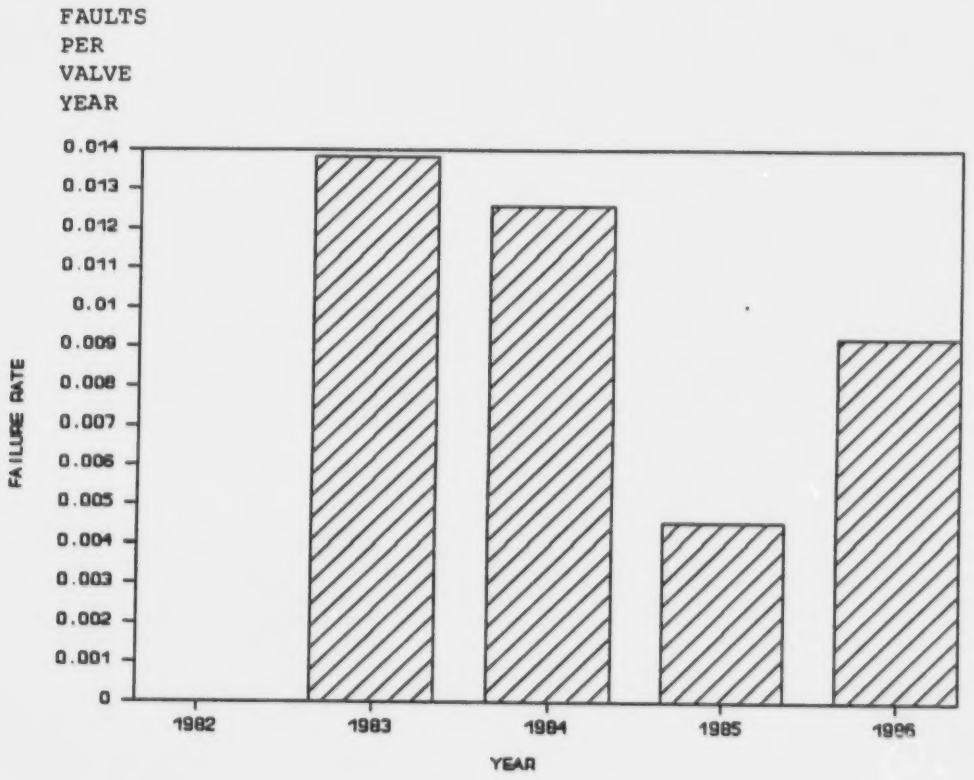


FIGURE A-3-3: FAILURE FRACTION BY YEAR
PICKERING B - ALL UNITS

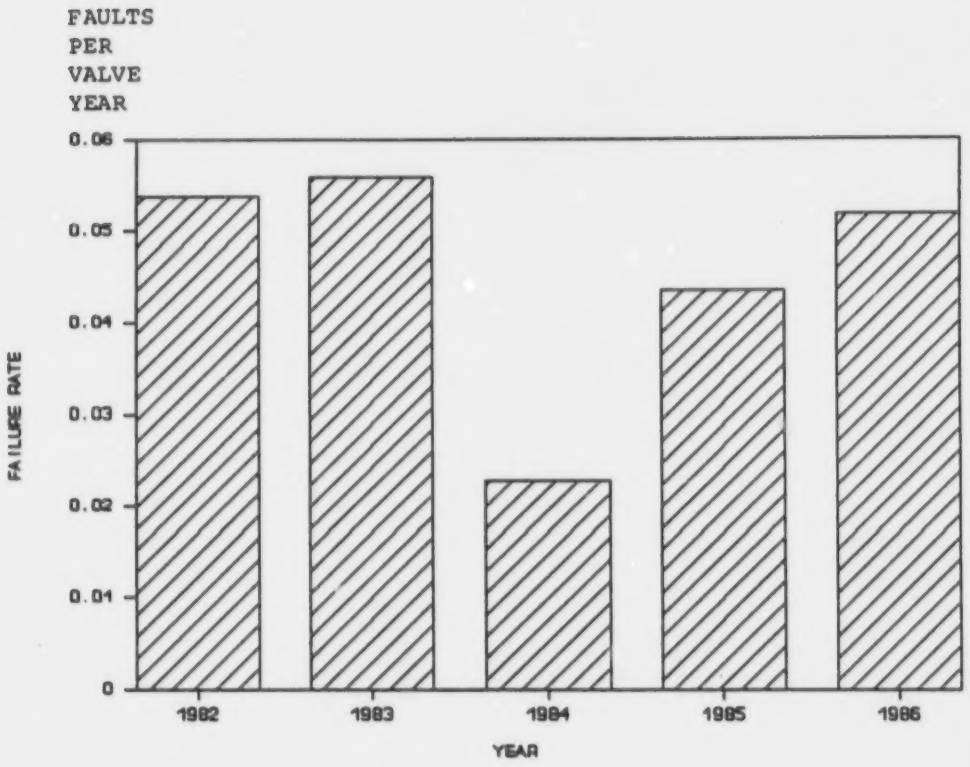


FIGURE A-3-4: FAILURE FRACTION BY YEAR
BRUCE A - ALL UNITS

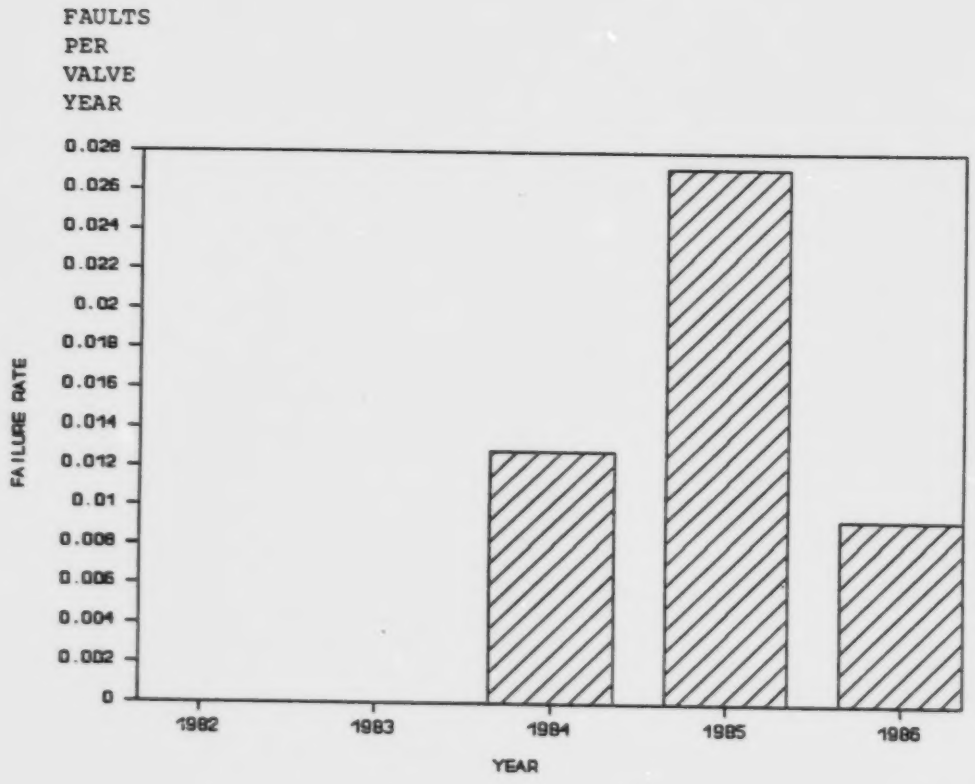


FIGURE A-3-5: FAILURE FRACTION BY YEAR
BRUCE B - ALL UNITS

SERIES IV - FAILURE FRACTION BY AGE

LEAD SHEET

DESCRIPTION: Failure fraction of valves vs. age of unit in which valves are installed.

SYSTEMS: ECC, SDS2, CONT.

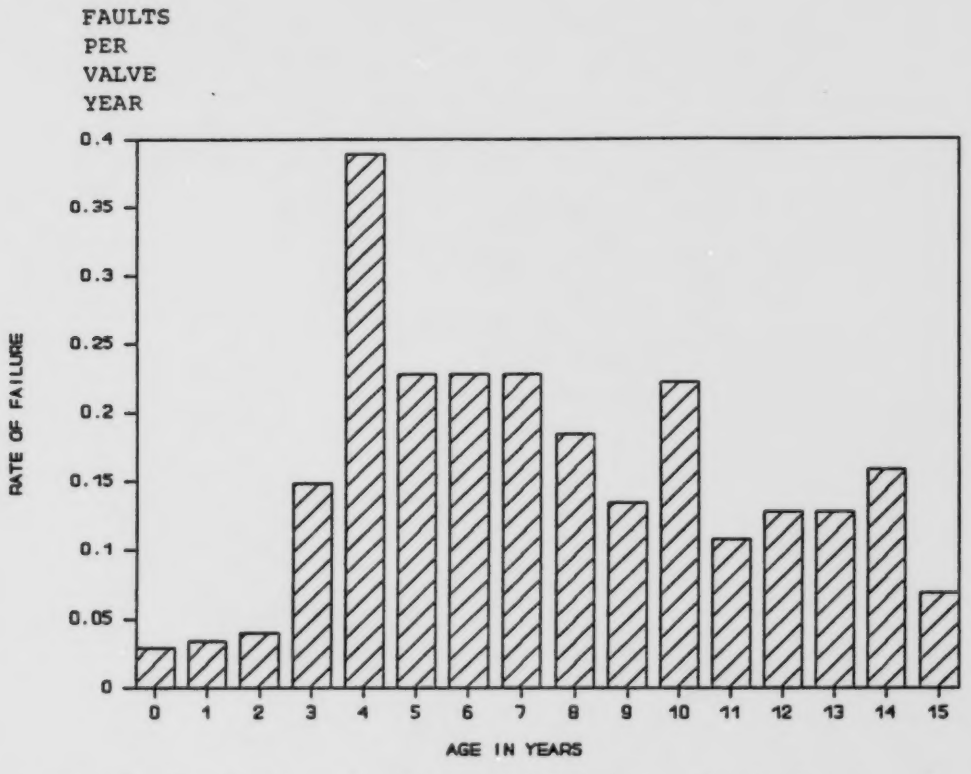
SITES: Pickering A, Pickering B, Bruce A, Bruce B

METHOD OF CALCULATION:

$$\text{FAILURE FRACTION} = \frac{\text{Total quantity of reported valve failures for valves in units of a specific age from their inservice date}}{\text{Total quantity of valves in the units of this age}}$$

LIST OF FIGURES:

A-4-1	Failure	Fraction	by	Age	- All Valves
A-4-2	"	"	"	"	- Check Valves
A-4-3	"	"	"	"	- Isolating Valves
A-4-4	"	"	"	"	- Control Valves
A-4-5	"	"	"	"	- All Actuator Types
A-4-6	"	"	"	"	- Air Operated Valves
A-4-7	"	"	"	"	- MOV's



Total No. of Units in Service at this age: 7 5 3 2 2 4 4 4 3 3 2 4 2 2 2

Units in Service for which Data is Included

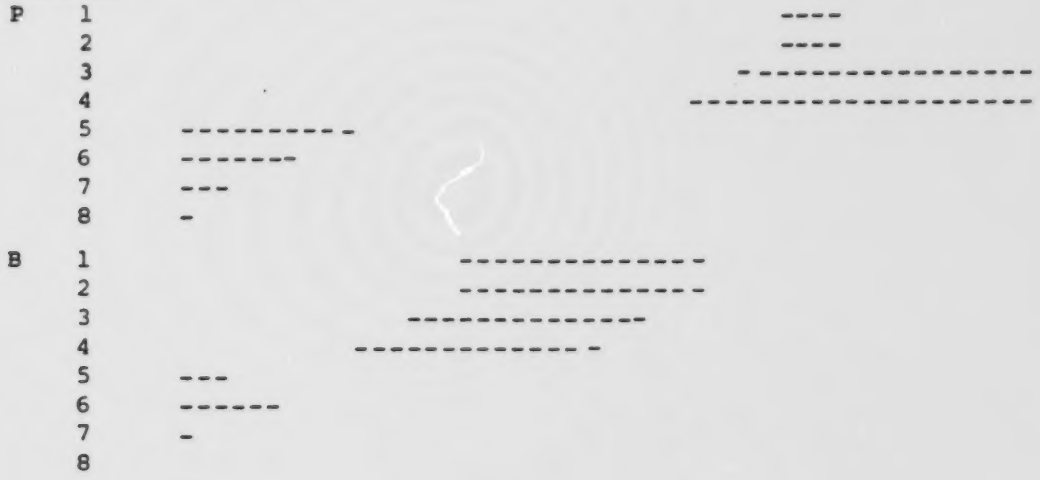


FIGURE A-4-1: FAILURE FRACTION BY AGE
ALL VALVES

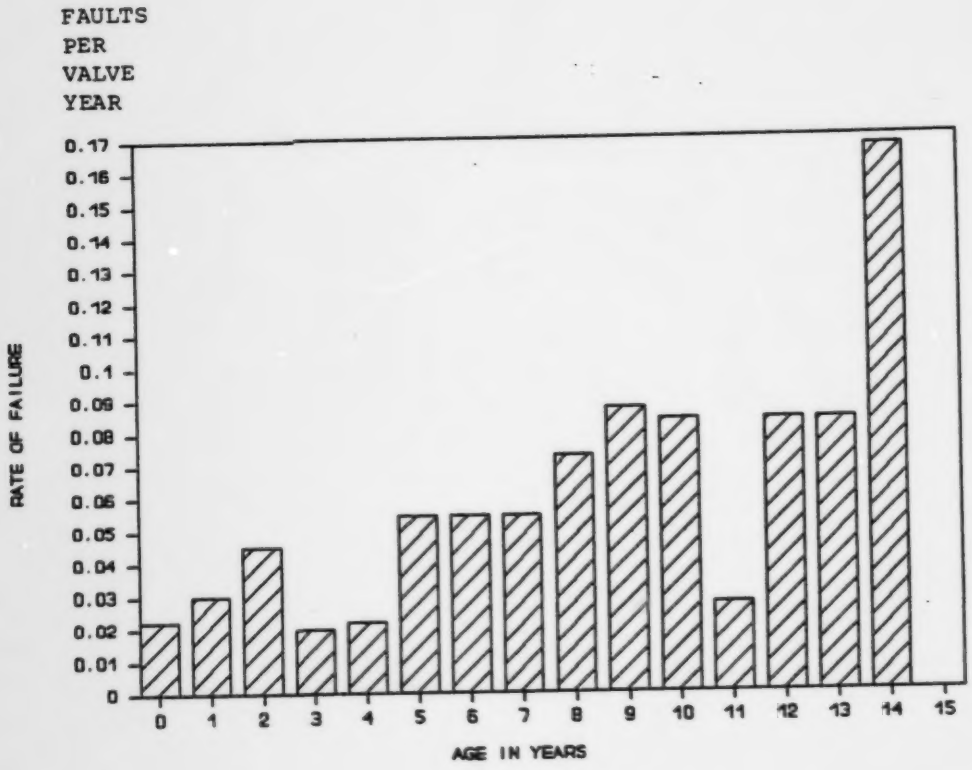


FIGURE A-4-2: FAILURE FRACTION BY AGE
CHECK VALVES

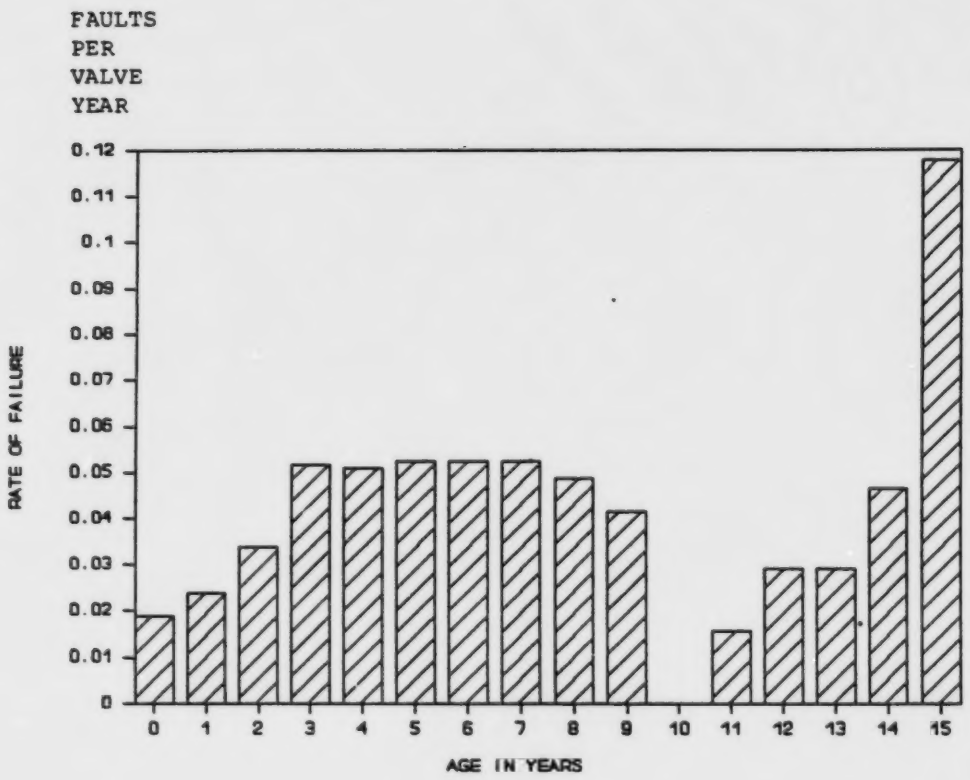


FIGURE A-4-3: FAILURE FRACTION BY AGE
ISOLATING VALVE

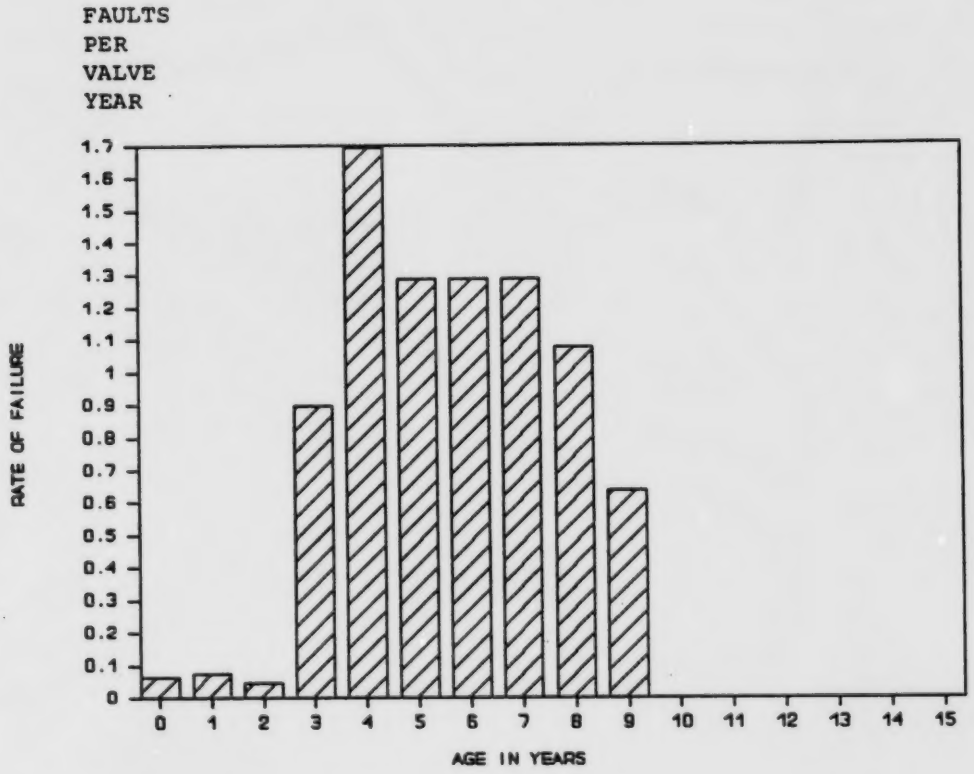


FIGURE A-4-4: FAILURE FRACTION BY AGE
CONTROL VALVES

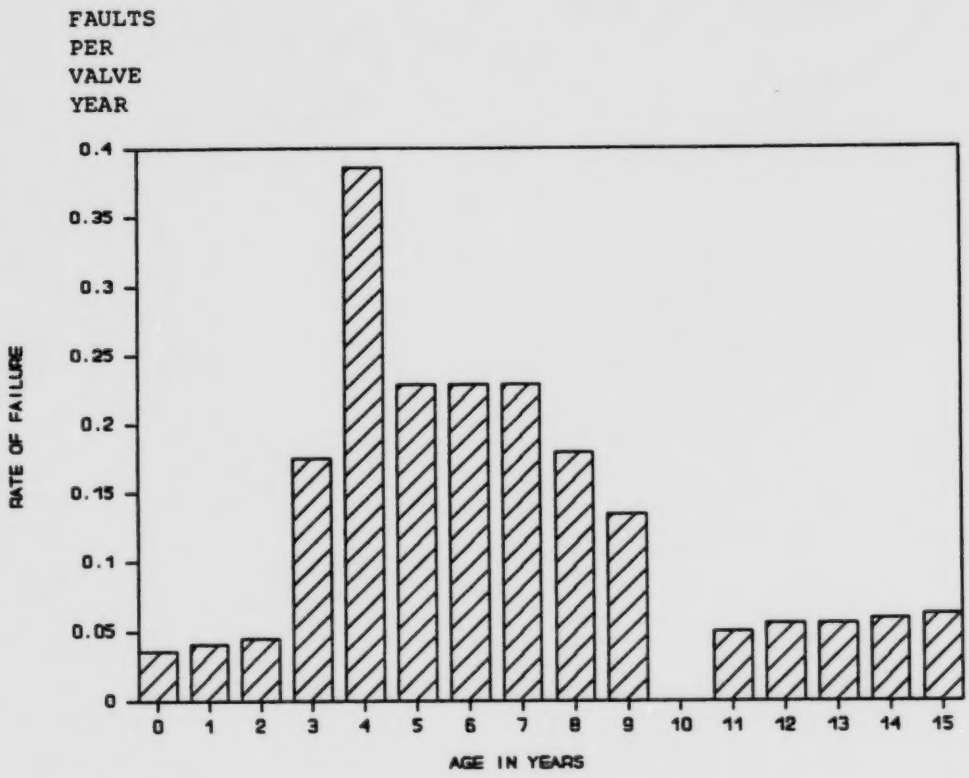


FIGURE A-4-5: FAILURE FRACTION BY AGE
ALL ACTUATOR TYPES

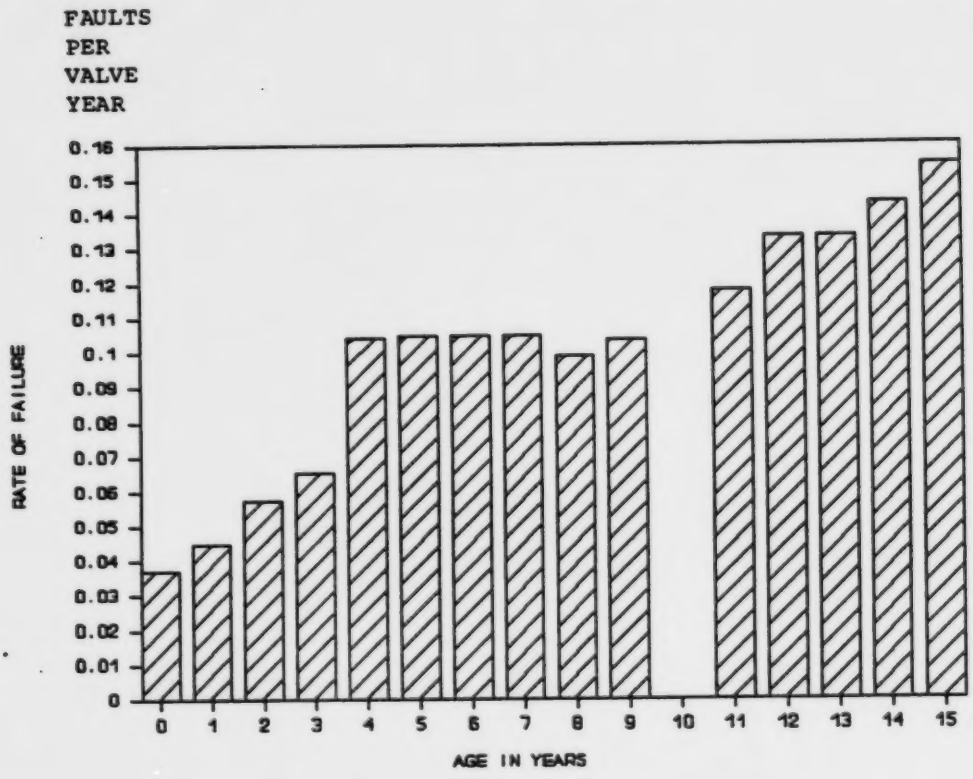


FIGURE A-4-6: FAILURE FRACTION BY AGE
AIR OPERATED VALVES

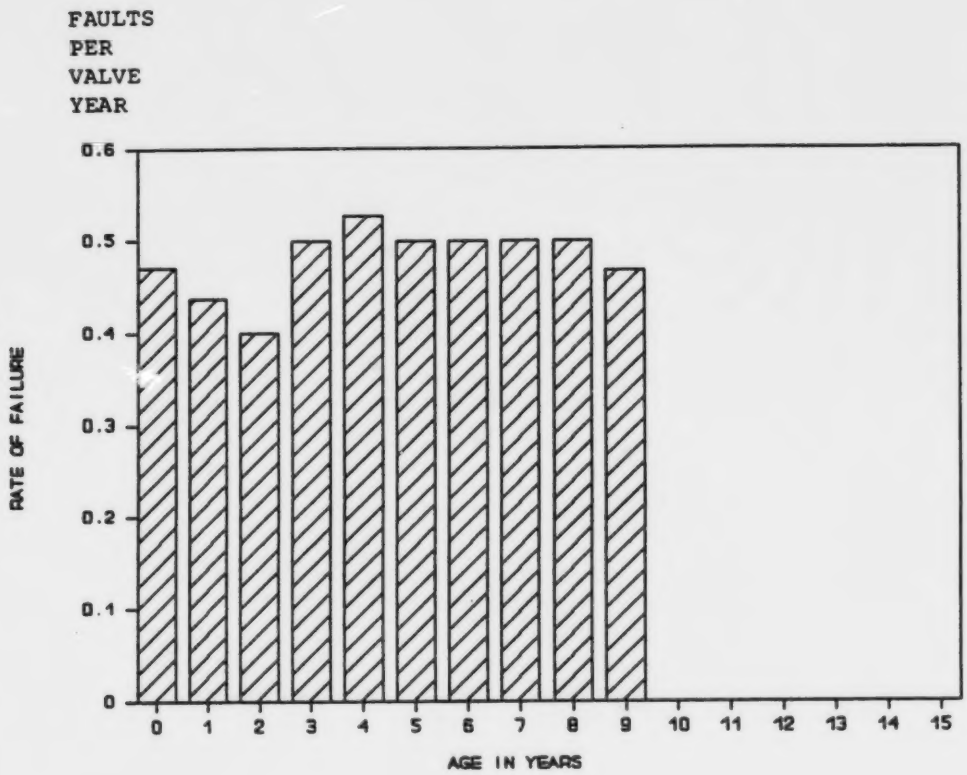


FIGURE A-4-7: FAILURE FRACTION BY AGE
MOTOR OPERATED VALVES

SERIES V - AVERAGE FAILURE

LEAD SHEET

DESCRIPTION: Average failure fraction for valves under consideration for the period 1982 to 1986 inclusive.

SYSTEMS: ECC, SDS2, CONT.

SITES: Pickering A, Pickering B, Bruce A, Bruce B

METHOD OF CALCULATION:

$$\text{FAILURE FRACTION} = \frac{\text{Total quantity of reported failures for valves in units of a particular site or system or of a particular type of function etc. for the period 1982 - 1986}}{\text{Total valve years of operation for this site, system, function or type, over this period 1982 - 1986}}$$

LIST OF FIGURES:

A-5-1 Average Failure Fraction by - Site

A-5-2 " " " " - System

A-5-3 " " " " - Function

A-5-4 " " " " - Actuator Type

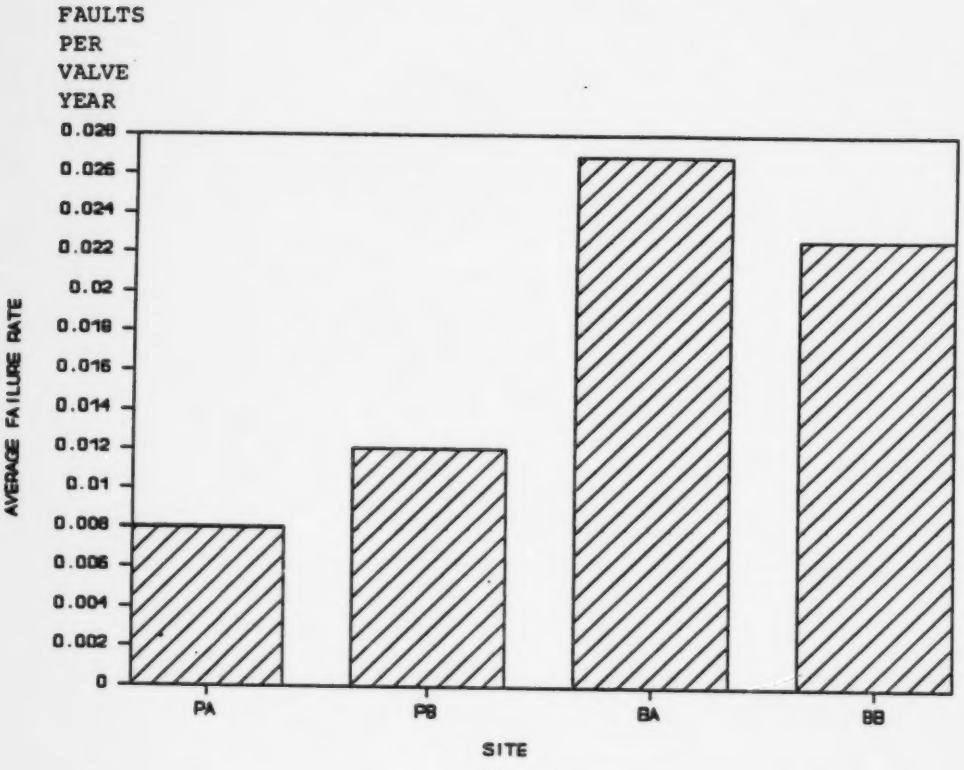


FIGURE A-5-1: AVERAGE FAILURE FRACTION
BY SITE

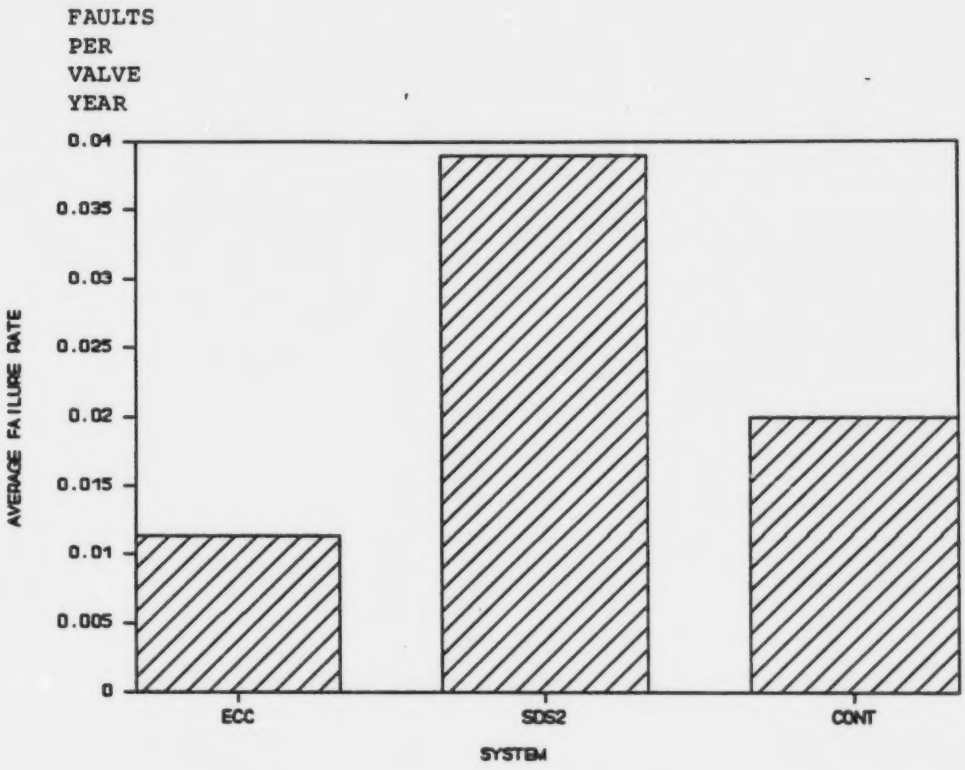


FIGURE A-5-2: AVERAGE FAILURE FRACTION
BY SYSTEM

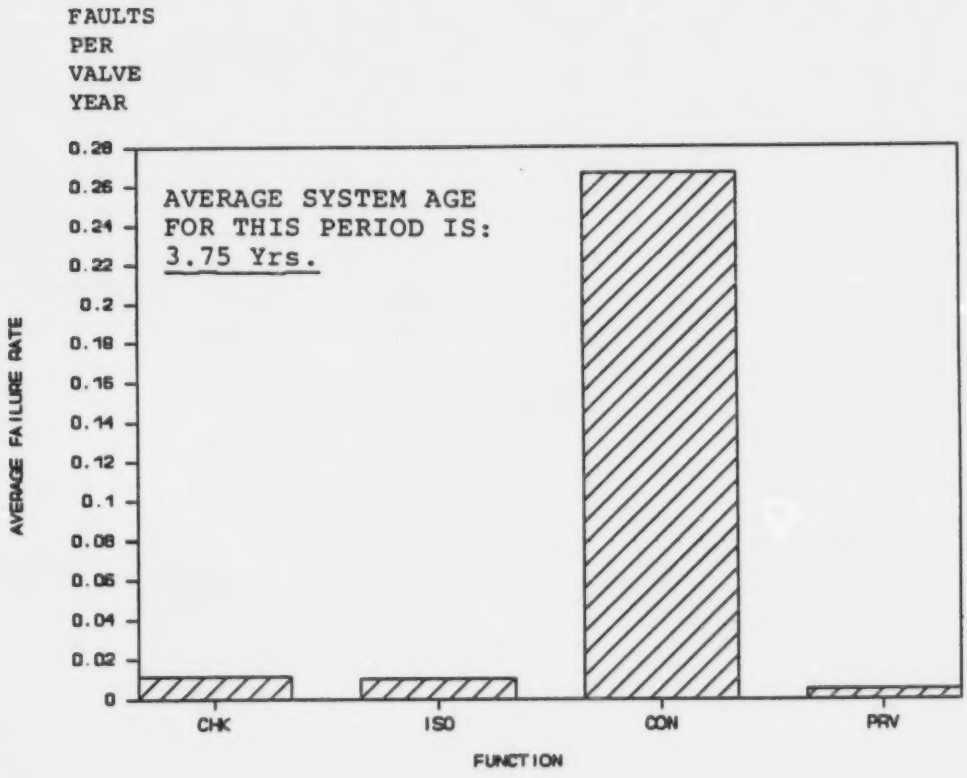


FIGURE A-5-3: AVERAGE FAILURE FRACTION
BY FUNCTION

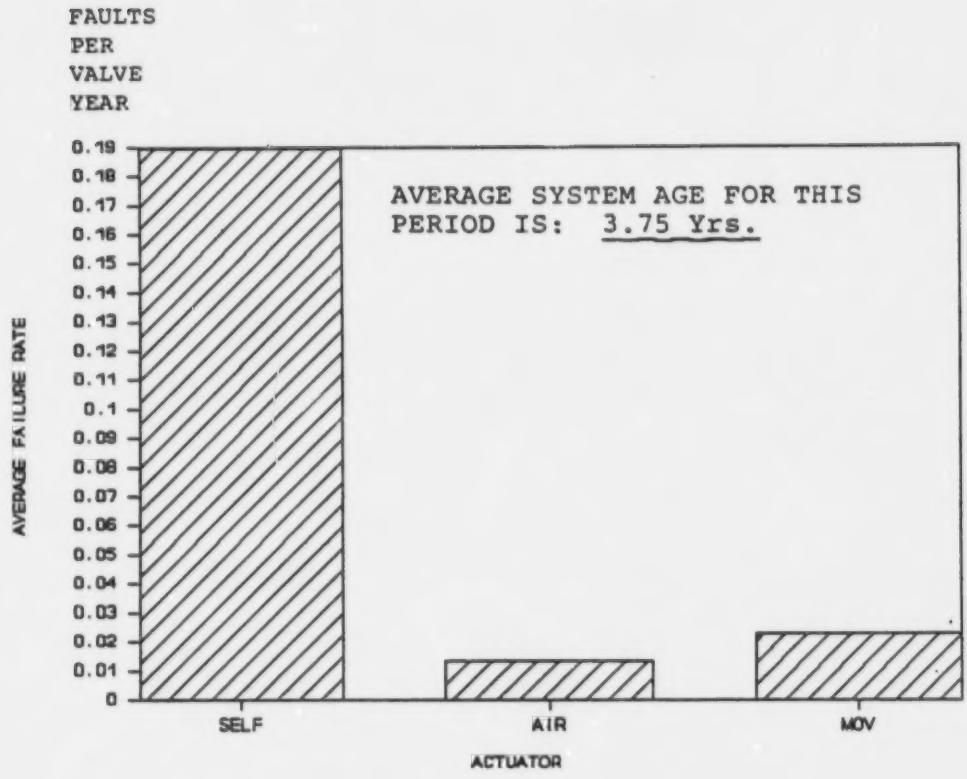


FIGURE A-5-4: AVERAGE FAILURE FRACTION BY ACTUATOR

APPENDIX B

VALVE DATA BASE

CONTENTS

PART I	VALVE POPULATION	-	Lead Sheet
		-	Printout
PART II	FAILURE POPULATION	-	Lead Sheet
		-	Printout
PART III	DESIGN DATA	-	Lead Sheet
		-	Printout

ABBREVIATIONS USED IN THIS APPENDIX

AIR	-	Air Actuated Valve
B	-	Bruce
CHECK	-	Check Valve
CONT	-	Containment System
Ctrl.	-	Control Valve
ECC	-	Emergency Core Cooling
EXL	-	External Leaks
FC	-	Failed Closed
FO	-	Failed Open
FTC	-	Failed to Close
FTO	-	Failed to Open
FTS	-	Failed to Stroke
HYD	-	Hydraulically Actuated Valve
IMOP	-	Improper Operation
INL	-	Internal Leak
Isol.	-	Isolating Valve
L	-	Leak
MAN	-	Manually Actuated Valve
MOV	-	Motor Operated Valve
P	-	Pickering
PROCESS TRANS	-	Process Transient
PRV	-	Pressure Regulating Valve
QTR	-	Quarterly Report
ROUTINE INS	-	Routine Inspection
SDS2	-	Safety Shutdown System 2

ABBREVIATIONS (CONT'D)

SELF	-	Self Actuated Valve
SER	-	Significant Event Report
SLOW	-	Slow to Operate
SOL	-	Solenoid Actuated Valve

PART I - VALVE POPULATION

LEAD SHEET

DESCRIPTION:	Quantities by site/unit as determined from review of operational flowsheets.
SYSTEMS:	ECC, SDS2, CONT.
SITES:	Pickering A, Pickering B, Bruce A, Bruce B, Point LePreau, Gentilly

COLUMN HEADINGS		CONTENTS
INDEX	-	NEL/SEL ENTRY NO.
U	-	UNIT NUMBER*
USI	-	USI NO.
CODE	-	COMPONENT CODE
FUNCTION	-	CHECK, CTRL, ISOL, PRV
TYPE	-	BALL, BUTTERFLY, GATE, GLOBE
ACTUATOR	-	AIR, HYD, MAN, MOV, SELF, SOL
FLOWSHEET	-	AECL OPERATIONAL FLOWSHEET NO.
R	-	REVISION
GRID	-	LOCATION OF DRAWING
UNITS	-	UNIT NUMBERS CONTAINING THIS VALVE

* In the Valve Population Database tables, Unit No."1" is used exclusively under the 'U' column. In multi-unit plants, the proper valve designations can be found by substituting the correct unit numbers from the "UNITS" column for the number "1" in the "U" column.

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE A - CONTAINMENT SYSTEM *

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
34220-MV3	ISOL	-0-	-0-	RMEP-IR-03624-8			1
67878-SV36P	ISOL	-0-	MOV	NK21-OP-67878-FS-1			1
34220-MV56	ISOL	-0-	-0-	RMEP-IR-03624-8			1
67878-SV36N	ISOL	-0-	MOV	NK21-OP-67878-FS-1			1
67878-SV27P	ISOL	-0-	MOV	NK21-OP-67878-FS-1			1
34220-MV1	ISOL	-0-	-0-	RMEP-IR-03624-8			1
34220-MV2	ISOL	-0-	-0-	RMEP-IR-03624-8			1
67878-SV35P	ISOL	-0-	MOV	NK21-OP-67878-FS-1			1
34220-MV29	ISOL	-0-	-0-	RMEP-IR-03624-8			1
67878-SV35N	ISOL	-0-	MOV	NK21-OP-67878-FS-1			1
38340-MV1	ISOL	-0-	MOV	RMEP-IR-03624-8			1
38310-MV16	ISOL	-0-	MOV	RMEP-IR-03624-8			1
34220-MV30	ISOL	-0-	-0-	RMEP-IR-03624-8			1
38310-MV15	ISOL	-0-	MOV	RMEP-IR-03624-8			1
67878-SV27N	ISOL	-0-	MOV	NK21-OP-67878-FS-1			1
34220-MV16	ISOL	-0-	-0-	RMEP-IR-03624-8			1
34220-MV15	ISOL	-0-	-0-	RMEP-IR-03624-8			1
38340-MV2	ISOL	-0-	MOV	RMEP-IR-03624-8			1

* The two sets of 16 pressure relief valves in the pressure relief vacuum manifold at Bruce A and Bruce B have been omitted from the valve population database due to their unique style.

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE A - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34340-V166	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	3E	0	1
1-34340-V320	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	1D	0	1
1-34340-MV303-PRV1	CTRL	-0-	SELF	NK21-OP-34340-FS-1	3	6C	0	1
1-34340-NV120	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	4D	0	1
1-34340-MV308-PRV1	CTRL	-0-	SELF	NK21-OP-34340-FS-1	3	5B	0	1
1-34340-V325	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34340-RV192	PRV	-0-	-0-	NK21-OP-34340-FS-2	3	2D	0	1
1-34340-MV384	ISOL	BALL	AIR	NK21-OP-34340-FS-1	3	1B	0	1
1-34340-V328	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	2E	0	1
1-34340-MV368	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	1B	0	1
1-34340-RV330	PRV	-0-	-0-	NK21-OP-34340-FS-1	3	4B	0	1
1-34340-MV104	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	4E	0	1
1-34340-V118	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	3D	0	1
1-34330-MV122	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	3C	1-4	4
1-34340-RV311	PRV	-0-	-0-	NK21-OP-34340-FS-1	3	3B	0	1
1-34330-MV16	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	6D	1-4	4
1-34340-V444	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	2E	0	1
1-34340-V148	ISOL	BALL	MOV	NK21-OP-34340-FS-2	2	3C	0	1
1-34340-RV329	PRV	-0-	-0-	NK21-OP-34340-FS-1	3	1A	0	1
1-34330-MV13	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	1D	1-4	4
1-34340-V117	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	3D	0	1
1-34340-MV140	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	3C	0	1
1-34340-RV318	PRV	-0-	-0-	NK21-OP-34340-FS-1	3	1A	0	1
1-34330-MV14	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	2E	1-4	4
1-34340-MV109	ISOL	BALL	AIR	NK21-OP-34340-FS-2	2	1E	0	1
1-34330-MV120	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	3C	1-4	4
1-34340-NV123	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	3D	0	1
1-34340-MV114	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	2E	0	1
1-34340-MV304-V2	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	6C	0	1
1-34330-MV111	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	3B	1-4	4
1-34340-NV115	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	3D	0	1
1-34340-MV304-SV1	CTRL	-0-	SOL	NK21-OP-34340-FS-1	3	6C	0	1
1-34340-V108	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	4D	0	1
1-34340-NV105	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	5D	0	1
1-34340-V306	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	2A	0	1
1-34340-NV385	CHECK	-0-	-0-	NK21-OP-34340-FS-1	3	2B	0	1
1-34340-V335	ISOL	GLOBE	MAN	NK21-OP-34340-FS-1	3	1A	0	1
1-34340-MV142	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	2C	0	1
1-34340-V112	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	2E	0	1
1-34340-V147	ISOL	BALL	MOV	NK21-OP-34340-FS-2	2	3C	0	1
1-34340-V194	ISOL	BALL	MAN	NK21-OP-34340-FS-2	2	1F	0	1
1-34340-V146	ISOL	BALL	MOV	NK21-OP-34340-FS-2	2	4C	0	1
1-34330-NV22	CHECK	-0-	-0-	NK21-OP-34330-FS-1	4	3C	1-4	4
1-34330-MV7	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	3E	1-4	4
1-34340-V308	ISOL	GATE	AIR	NK21-OP-34340-FS-1	3	2B	0	1
1-34330-MV6	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	2E	1-4	4
1-34340-V107	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	4D	0	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE A - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34330-MV119	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	2C	1-4	4
1-34340-V170	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	2E	0	1
1-34330-MV101	ISOL	-0-	MOV	NK21-OP-34330-FS-1	4	5B	1-4	4
1-34340-V312	CTRL	GLOBE	MAN	NK21-OP-34340-FS-1	3	3D	0	1
1-34330-MV105	ISOL	-0-	MOV	NK21-OP-34330-FS-1	4	5B	1-4	4
1-34340-PCV309-V1	ISOL	-0-	MAN	NK21-OP-34340-FS-1	3	5B	0	1
1-34330-MV110	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	3B	1-4	4
1-34340-V394	ISOL	BALL	MAN	NK21-OP-34340-FS-1	3	2B	0	1
1-34340-V439	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	3E	0	1
1-34340-V302	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	2A	0	1
1-34340-V322	ISOL	GLOBE	MAN	NK21-OP-34340-FS-1	3	1D	0	1
1-34340-V391	ISOL	BALL	MAN	NK21-OP-34340-FS-1	3	2A	0	1
1-34340-NV116	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	2D	0	1
1-34340-V145	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	1C	0	1
1-34340-NV124	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	2D	0	1
1-34340-V353	ISOL	GLOBE	MAN	NK21-OP-34340-FS-1	3	1D	0	1
1-34340-NV156	CHECK	-0-	-0-	NK21-OP-34340-FS-1	3	4E	0	1
1-34340-MV304-V1	ISOL	GATE	-0-	NK21-OP-34340-FS-1	3	6C	0	1
1-34340-NV157	CHECK	-0-	-0-	NK21-OP-34340-FS-1	3	5E	0	1
1-34340-PCV309	CTRL	-0-	SELF	NK21-OP-34340-FS-1	3	2B	0	1
1-34340-NV158	CHECK	-0-	-0-	NK21-OP-34340-FS-1	3	4E	0	1
1-34330-MV131	ISOL	-0-	AIR	NK21-OP-34330-FS-1	4	4C	1-4	4
1-34340-V102	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34340-NV106	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	4D	0	1
1-34340-RV136	PRV	-0-	-0-	NK21-OP-34340-FS-1	3	3D	0	1
1-34340-V380	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	1B	0	1
1-34340-RV135	PRV	-0-	-0-	NK21-OP-34340-FS-1	3	3D	0	1
1-34340-MV304	ISOL	BUTT	AIR	NK21-OP-34340-FS-1	3	2A	0	1
1-34340-RV134	PRV	-0-	-0-	NK21-OP-34340-FS-2	3	4D	0	1
1-34340-V381	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	1B	0	1
1-34340-RV133	PRV	-0-	-0-	NK21-OP-34340-FS-2	3	5D	0	1
1-34340-NV119	CHECK	-0-	-0-	NK21-OP-34340-FS-2	2	5D	0	1
1-34340-RV383	PRV	-0-	-0-	NK21-OP-34340-FS-2	3	2A	0	1
1-34340-MV303	ISOL	BUTT	AIR	NK21-OP-34340-FS-1	3	2A	0	1
1-34340-RV418	PRV	-0-	-0-	NK21-OP-34340-FS-2	3	2C	0	1
1-34330-MV123	ISOL	GATE	AIR	NK21-OP-34330-FS-1	4	4C	1-4	4
1-34340-MV339	ISOL	GATE	AIR	NK21-OP-34340-FS-1	3	3D	0	1
1-34330-MV112	ISOL	GATE	AIR	NK21-OP-34330-FS-1	4	3B	1-4	4
1-34340-MV180	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	4C	0	1
1-34330-NV117	CHECK	-0-	AIR	NK21-OP-34330-FS-1	4	3C	1-4	4
1-34340-PCV309-PRV1	CTRL	-0-	SELF	NK21-OP-34340-FS-1	3	5B	0	1
1-34330-MV108	ISOL	-0-	AIR	NK21-OP-34330-FS-1	4	4B	1-4	4
1-34340-MV113	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	3E	0	1
1-34330-MV114	ISOL	GATE	AIR	NK21-OP-34330-FS-1	4	3A	1-4	4
1-34340-PRV344	CTRL	BUTT	AIR	NK21-OP-34340-FS-1	3	3A	0	1
1-34330-MV132	ISOL	-0-	AIR	NK21-OP-34330-FS-1	4	4B	1-4	4
1-34340-MV103	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	4E	0	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE A - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34330-V129	ISOL	GATE	MAN	NK21-OP-34330-FS-1	4	4B	1-4	4
1-34340-MV303-SV1	CTRL	-0-	SOL	NK21-OP-34340-FS-1	3	6C	0	1
1-34340-NV155	CHECK	-0-	-0-	NK21-OP-34340-FS-1	3	5E	0	1
1-34340-PRV348	CTRL	-0-	-0-	NK21-OP-34340-FS-1	3	2D	0	1
1-34340-V167	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	2E	0	1
1-34340-?	-0-	-0-	-0-	NK21-OP-34340-FS-1	3	2D	0	1
1-34330-MV109	ISOL	GATE	AIR	NK21-OP-34330-FS-1	4	3B	1-4	4
1-34340-MV144	ISOL	-0-	MOV	NK21-OP-34340-FS-2	2	3D	0	1
1-34340-MV386	ISOL	BALL	AIR	NK21-OP-34340-FS-1	3	2B	0	1
1-34330-MV121	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	2C	1-4	4
1-34340-MV314	ISOL	GATE	HYD	NK21-OP-34340-FS-1	3	2E	0	1
1-34330-MV106	ISOL	-0-	MOV	NK21-OP-34330-FS-1	4	5B	1-4	4
1-34340-V169	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	2E	0	1
1-34340-V438	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34330-MV113	ISOL	GATE	AIR	NK21-OP-34330-FS-1	4	3A	1-4	4
1-34340-V101	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34340-V359	ISOL	BALL	MAN	NK21-OP-34340-FS-1	3	3E	0	1
1-34340-MV110	ISOL	BALL	AIR	NK21-OP-34340-FS-2	2	1E	0	1
1-34340-MV323	ISOL	GATE	HYD	NK21-OP-34340-FS-1	3	2E	0	1
1-34340-V440	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	3E	0	1
1-34340-V366	ISOL	BALL	MAN	NK21-OP-34340-FS-1	3	3B	0	1
1-34330-NV23	ISOL	GATE	MAN	NK21-OP-34330-FS-1	4	3C	1-4	4
1-34330-MV3	ISOL	GATE	HYD	NK21-OP-34330-FS-1	4	4B	1-4	4
1-34340-V437	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34340-MV324	ISOL	GATE	HYD	NK21-OP-34340-FS-1	3	2E	0	1
1-34340-V111	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	3E	0	1
1-34340-MV308-V1	ISOL	DIA	MAN	NK21-OP-34340-FS-1	3	5B	0	1
1-34330-MV15	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	3E	1-4	4
1-34340-V307	CTRL	GLOBE	MAN	NK21-OP-34340-FS-1	3	2B	0	1
1-34340-MV137	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	3D	0	1
1-34340-V414	ISOL	BALL	MAN	NK21-OP-34340-FS-1	3	1B	0	1
1-34340-MV308-SV1	CTRL	-0-	SOL	NK21-OP-34340-FS-1	3	5B	0	1
1-34340-V345	ISOL	GLOBE	MAN	NK21-OP-34340-FS-1	3	3A	0	1
1-34340-MV303-V1	ISOL	GATE	-0-	NK21-OP-34340-FS-1	3	6C	0	1
1-34330-MV2	ISOL	GATE	HYD	NK21-OP-34330-FS-1	4	4B	1-4	4
1-34340-MV179	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	4C	0	1
1-34340-MV313	ISOL	GATE	HYD	NK21-OP-34340-FS-1	3	2E	0	1
1-34330-MV102	ISOL	-0-	MOV	NK21-OP-34330-FS-1	4	5B	1-4	4
1-34340-MV303-V2	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	6C	0	1
1-34340-V326	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34340-V305	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	2A	0	1
1-34340-V442	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34340-V301	ISOL	GATE	MAN	NK21-OP-34340-FS-1	3	2A	0	1
1-34340-V413	ISOL	BALL	MAN	NK21-OP-34340-FS-1	3	1B	0	1
1-34340-V336	ISOL	GLOBE	MAN	NK21-OP-34340-FS-1	3	1A	0	1
1-34330-NV118	CHECK	-0-	AIR	NK21-OP-34330-FS-1	4	3C	1-4	4
1-34340-V365	ISOL	BALL	MAN	NK21-OP-34340-FS-1	3	1A	0	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE A - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34340-MV138	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	4D	0	1
1-34340-V352	ISOL	GLOBE	MAN	NK21-OP-34340-FS-1	3	1D	0	1
1-34340-MV139	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	3C	0	1
1-34330-MV409	ISOL	GATE	AIR	NK21-OP-34330-FS-1	4	4C	1-4	4
1-34340-MV367	ISOL	BUTT	MOV	NK21-OP-34340-FS-2	2	1B	0	1
1-34340-V321	ISOL	GLOBE	MAN	NK21-OP-34340-FS-1	3	1D	0	1
1-34340-V327	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	3E	0	1
1-34330-NV115	CHECK	-0-	AIR	NK21-OP-34330-FS-1	4	3C	1-4	4
1-34340-MV304-PRV1	CTRL	-0-	SELF	NK21-OP-34340-FS-1	3	6C	0	1
1-34340-V379	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	1B	0	1
1-34330-MV4	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	1D	1-4	4
1-34340-V378	ISOL	BUTT	MAN	NK21-OP-34340-FS-2	2	1B	0	1
1-34340-V443	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	3E	0	1
1-34340-V441	ISOL	GATE	MAN	NK21-OP-34340-FS-2	2	4E	0	1
1-34330-MV5	ISOL	GATE	MOV	NK21-OP-34330-FS-1	4	5D	1-4	4
1-34330-NV116	CHECK	-0-	AIR	NK21-OP-34330-FS-1	4	3C	1-4	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE A - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-31760-NV9	CHECK	-0-	-0-	NK21-OP-31760-FS-1	6	2A	1-4	4
1-31760-V13	ISOL	GLOBE	MAN	NK21-OP-31760-FS-1	6	3B	1-4	4
1-31760-V114	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	3B	1-4	4
1-31760-V16	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	3B	1-4	4
1-31760-PRV7	CTRL	GLOBE	SELF	NK21-OP-31760-FS-1	6	1A	1-4	4
1-31760-NV121	CHECK	-0-	-0-	NK21-OP-31760-FS-1	6	3A	1-4	4
1-31760-V25	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	2D	1-4	4
1-31760-NV123	CHECK	-0-	-0-	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V27	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	4D	1-4	4
1-31760-V119	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	5B	1-4	4
1-31760-V29	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	5D	1-4	4
1-31760-V116	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	3B	1-4	4
1-31760-V106	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	4D	1-4	4
1-31760-V118	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V115	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	2B	1-4	4
1-31760-V17	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V108	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	5D	1-4	4
1-31760-V117	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V107	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	4D	1-4	4
1-31760-NV122	CHECK	-0-	-0-	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V105	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	2D	1-4	4
1-31760-MV4	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	2A	1-4	4
1-31760-V28	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	4D	1-4	4
1-31760-V15	ISOL	GLOBE	MAN	NK21-OP-31760-FS-1	6	2B	1-4	4
1-31760-V24	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	3D	1-4	4
1-31760-MV1G	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	3A	1-4	4
1-31760-V19	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V20	ISOL	GLOBE	MAN	NK21-OP-31760-FS-1	6	5B	1-4	4
1-31760-MV3G	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	3A	1-4	4
1-31760-MV2J	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	4A	1-4	4
1-31760-V113	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	3B	1-4	4
1-31760-MV21	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	5B	1-4	4
1-31760-V14	ISOL	GLOBE	MAN	NK21-OP-31760-FS-1	6	2B	1-4	4
1-31760-MV3J	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V109	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	5D	1-4	4
1-31760-V10	ISOL	GLOBE	MAN	NK21-OP-31760-FS-1	6	2A	1-4	4
1-31760-RV6	PRV	-0-	-0-	NK21-OP-31760-FS-1	6	2A	1-4	4
1-31760-MV2H	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-RV5	PRV	-0-	-0-	NK21-OP-31760-FS-1	6	2A	1-4	4
1-31760-V33	ISOL	GLOBE	MAN	NK21-OP-31760-FS-1	6	2A	1-4	4
1-31760-V23	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	3D	1-4	4
1-31760-MV1J	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	3B	1-4	4
1-31760-V8	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	2A	1-4	4
1-31760-MV3H	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V26	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	3D	1-4	4
1-31760-MV2G	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	4A	1-4	4
1-31760-V104	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	3D	1-4	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE A - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-31760-V18	ISOL	GATE	MAN	NK21-OP-31760-FS-1	6	4B	1-4	4
1-31760-V103	ISOL	BALL	MAN	NK21-OP-31760-FS-1	6	3D	1-4	4
1-31760-MV1H	ISOL	GLOBE	AIR	NK21-OP-31760-FS-1	6	3A	1-4	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE B - CONTAINMENT SYSTEM*

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
34220-MV16	ISOL	BUTT	AIR	D&D REPORT #85404			1
78780-MV41	ISOL	-0-	AIR	D&D REPORT #85404			1
34220-MV15	ISOL	BUTT	AIR	D&D REPORT #85404			1
78780-MV124	ISOL	-0-	AIR	D&D REPORT #85404			1
34220-MV1	ISOL	BUTT	AIR	D&D REPORT #85404			1
34110-MV94	ISOL	GLOBE	AIR	D&D REPORT #85404			1
71330-MV511	ISOL	-0-	AIR	D&D REPORT #85404			1
34220-MV3	ISOL	BUTT	AIR	D&D REPORT #85404			1
71330-MV509	ISOL	-0-	AIR	D&D REPORT #85404			1
78780-MV40	ISOL	-0-	AIR	D&D REPORT #85404			1
78780-MV125	ISOL	-0-	AIR	D&D REPORT #85404			1
34110-MV93	ISOL	GLOBE	AIR	D&D REPORT #85404			1
34220-MV2	ISOL	BUTT	AIR	D&D REPORT #85404			1

* The two sets of 16 pressure relief valves in the pressure relief vacuum manifold at Bruce A and Bruce B have been omitted from the valve population database due to their unique style.

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE B - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VAL
1-34340-MV304-V2	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-RV136	PRV	-0-	-0-	NK29-FXX-34340-0002-06			0	1
1-34340-V436	ISOL	GLOBE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-RV383	PRV	-0-	-0-	NK29-FXX-34340-0002-06			0	1
1-34340-NV158	CHECK	-0-	-0-	NK29-FXX-34340-0001	4	6D	0	1
1-34340-?	-0-	-0-	-0-	NK29-FXX-34340-0001	4		0	1
1-34340-MV384	ISOL	BALL	AIR	NK29-FXX-34340-0001	4	3B	0	1
1-34340-RV311	PRV	-0-	-0-	NK29-FXX-34340-0001-06			0	1
1-34340-V325	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-MV109	ISOL	GATE	AIR	NK29-FXX-34340-0002-06			0	1
1-34340-NV157	CHECK	-0-	-0-	NK29-FXX-34340-0001	4	6D	0	1
1-34340-V439	ISOL	GLOBE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V302	ISOL	GATE	MAN	NK29-FXX-34340-0001	4	7A	0	1
1-34340-V102	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34330-NV401	CHECK	-0-	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34340-MV144	ISOL	-0-	MOV	NK29-FXX-34340-0002-06			0	1
1-34340-MV303-SV1	CTRL	-0-	SOL	NK29-FXX-34340-0001	4		0	1
1-34340-MV110	ISOL	GATE	AIR	NK29-FXX-34340-0002-06			0	1
1-34340-MV339	ISOL	GATE	AIR	NK29-FXX-34340-0001	4		0	1
1-34340-V111	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V327	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V112	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V305	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-V199	ISOL	GATE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-PRV344	CTRL	-0-	AIR	NK29-FXX-34340-0001	4		0	1
1-34340-MV386	ISOL	BALL	AIR	NK29-FXX-34340-0001	4		0	1
1-34340-PCV309-PRV1	CTRL	-0-	SELF	NK29-FXX-34340-0001	4		0	1
1-34330-V23	ISOL	GATE	MAN	NK29-FOX-34330-0001-05			5-8	4
1-34340-MV308-PRV1	CTRL	-0-	SELF	NK29-FXX-34340-0001	4		0	1
1-34340-MV103	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06			0	1
1-34340-PCV309	CTRL	-0-	SELF	NK29-FXX-34340-0001	4		0	1
1-34340-MV104	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06			0	1
1-34330-NV22	CHECK	-0-	-0-	NK29-FOX-34330-0001-05			5-8	4
1-34340-V167	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-MV303-PRV1	CTRL	-0-	SELF	NK29-FXX-34340-0001	4		0	1
1-34340-MV113	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06			0	1
1-34340-V437	ISOL	GATE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V379	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V196	ISOL	GATE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V380	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34330-MV131	ISOL	-0-	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34340-MV114	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06			0	1
1-34330-MV112	ISOL	GATE	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34340-MV303	ISOL	BUTT	AIR	NK29-FXX-34340-0001	4		0	1
1-34330-MV114	ISOL	GATE	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34340-V320	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34330-NV403	CHECK	-0-	AIR	NK29-FOX-34330-0001-05			5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE B - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VAL
1-34340-V321	ISOL	GLOBE	MAN	NK29-FXX-34340-0001	4	0	1
1-34330-NV118	CHECK	-0-	AIR	NK29-FOX-34330-0001-05		5-8	4
1-34340-NV105	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-V381	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06		0	1
1-34340-V322	ISOL	GLOBE	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-RV135	PRV	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34330-MV122	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34340-V414	ISOL	BALL	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-V352	ISOL	GLOBE	MAN	NK29-FXX-34340-0001	4	0	1
1-34330-V129	ISOL	GATE	MAN	NK29-FOX-34330-0001-05		5-8	4
1-34340-NV120	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-RV133	PRV	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34330-MV121	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34340-RV418	PRV	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34330-MV132	ISOL	-0-	AIR	NK29-FOX-34330-0001-05		5-8	4
1-34330-NV117	CHECK	-0-	AIR	NK29-FOX-34330-0001-05		5-8	4
1-34330-MV120	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34340-RV330	PRV	-0-	-0-	NK29-FXX-34340-0001-06		0	1
1-34330-MV109	ISOL	GATE	AIR	NK29-FOX-34330-0001-05		5-8	4
1-34340-MV368	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-V353	ISOL	GLOBE	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-NV155	CHECK	-0-	-0-	NK29-FXX-34340-0001	4	0	1
1-34340-NV123	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-RV329	PRV	-0-	-0-	NK29-FXX-34340-0001-06		0	1
1-34340-NV385	CHECK	-0-	-0-	NK29-FXX-34340-0001	4	0	1
1-34340-MV308-V1	ISOL	DIA	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-NV116	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-V145	ISOL	GATE	MAN	NK29-FXX-34340-0002-06		0	1
1-34330-MV119	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34330-NV402	CHECK	-0-	AIR	NK29-FOX-34330-0001-05		5-8	4
1-34340-V365	ISOL	BALL	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-NV124	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-MV304-V1	ISOL	GATE	-0-	NK29-FXX-34340-0001	4	0	1
1-34340-RV192	PRV	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34330-MV13	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34340-MV179	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-V335	ISOL	GLOBE	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-V107	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06		0	1
1-34330-MV4	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34340-MV137	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-NV106	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-NV156	CHECK	-0-	-0-	NK29-FXX-34340-0001	4	0	1
1-34340-V336	ISOL	GLOBE	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-MV304-SV1	CTRL	-0-	SOL	NK29-FXX-34340-0001	4	0	1
1-34330-MV14	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34340-V326	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06		0	1
1-34330-MV6	ISOL	GATE	MOV	NK29-FOX-34330-0001-05		5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE B - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VAL
1-34340-V101	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34330-MV15	ISOL	GATE	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-V432	ISOL	GLOBE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V391	ISOL	BALL	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-V435	ISOL	GLOBE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-V301	ISOL	GATE	MAN	NK29-FXX-34340-0001	4	2A	0	1
1-34340-MV303-V2	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-RV318	PRV	-0-	-0-	NK29-FXX-34340-0001-06			0	1
1-34340-V108	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06			0	1
1-34330-MV7	ISOL	GATE	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34330-NV116	CHECK	-0-	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34340-RV134	PRV	-0-	-0-	NK29-FXX-34340-0002-06			0	1
1-34330-MV123	ISOL	GATE	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34330-MV16	ISOL	GATE	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-V345	ISOL	GLOBE	MAN	NK29-FXX-34340-0001	4		0	1
1-34330-MV3	ISOL	-0-	HYD	NK29-FOX-34330-0001-05			5-8	4
1-34340-V394	ISOL	BALL	MAN	NK29-FXX-34340-0001	4		0	1
1-34330-MV5	ISOL	GATE	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-V169	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-MV303-V1	ISOL	GATE	-0-	NK29-FXX-34340-0001	4		0	1
1-34340-V312	CTRL	GLOBE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-MV313	ISOL	GATE	HYD	NK29-FXX-34340-0001	4		0	1
1-34340-PCV309-V1	ISOL	-0-	MAN	NK29-FXX-34340-0001	4		0	1
1-34330-MV111	ISOL	GATE	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-MV140	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06			0	1
1-34340-MV110	ISOL	GATE	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-V148	ISOL	BALL	MOV	NK29-FXX-34340-0002-06			0	1
1-34340-V308	ISOL	GATE	AIR	NK29-FXX-34340-0001	4		0	1
1-34340-V146	ISOL	BALL	MOV	NK29-FXX-34340-0002-06			0	1
1-34330-MV2	ISOL	-0-	HYD	NK29-FOX-34330-0001-05			5-8	4
1-34330-NV115	CHECK	-0-	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34330-MV106	ISOL	-0-	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-V438	ISOL	GLOBE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-MV314	ISOL	GATE	HYD	NK29-FXX-34340-0001	4		0	1
1-34340-MV308-SV1	CTRL	-0-	SOL	NK29-FXX-34340-0001	4		0	1
1-34330-MV105	ISOL	-0-	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-V306	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-MV323	ISOL	GATE	HYD	NK29-FXX-34340-0001	4		0	1
1-34340-MV304-PRV1	CTRL	-0-	SELF	NK29-FXX-34340-0001	4		0	1
1-34340-V170	ISOL	GATE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-V198	ISOL	GATE	MAN	NK29-FXX-34340-0002-06			0	1
1-34340-MV324	ISOL	GATE	HYD	NK29-FXX-34340-0001	4		0	1
1-34330-NV404	CHECK	-0-	AIR	NK29-FOX-34330-0001-05			5-8	4
1-34330-MV102	ISOL	-0-	MOV	NK29-FOX-34330-0001-05			5-8	4
1-34340-V307	CTRL	GLOBE	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-V366	ISOL	BALL	MAN	NK29-FXX-34340-0001	4		0	1
1-34340-MV367	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06			0	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE B - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VAL
1-34330-MV101	ISOL	-0-	MOV	NK29-FOX-34330-0001-05		5-8	4
1-34340-MV139	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-V378	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06		0	1
1-34340-MV180	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-NV115	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-V433	ISOL	GLOBE	MAN	NK29-FXX-34340-0002-06		0	1
1-34340-NV119	CHECK	-0-	-0-	NK29-FXX-34340-0002-06		0	1
1-34340-V328	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06		0	1
1-34340-V166	ISOL	GATE	MAN	NK29-FXX-34340-0001	4	0	1
1-34330-MV409	ISOL	GATE	AIR	NK29-FOX-34330-0001-05		5-8	4
1-34330-V113	ISOL	GATE	AIR	NK29-FOX-34330-0001-05		5-8	4
1-34340-V359	ISOL	BALL	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-PRV348	CTRL	-0-	-0-	NK29-FXX-34340-0001	4	0	1
1-34340-V147	ISOL	BALL	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-MV304	ISOL	BUTT	AIR	NK29-FXX-34340-0001	4	0	1
1-34340-V434	ISOL	GLOBE	MAN	NK29-FXX-34340-0002-06		0	1
1-34340-V117	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06		0	1
1-34340-V413	ISOL	BALL	MAN	NK29-FXX-34340-0001	4	0	1
1-34340-V197	ISOL	GATE	MAN	NK29-FXX-34340-0002-06		0	1
1-34340-MV138	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-MV142	ISOL	BUTT	MOV	NK29-FXX-34340-0002-06		0	1
1-34340-V118	ISOL	BUTT	MAN	NK29-FXX-34340-0002-06		0	1
1-34330-MV108	ISOL	-0-	AIR	NK29-FOX-34330-0001-05		5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE B - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-31760-NV53	CHECK	-0-	-0-	NK29-FXX-31760-0001	4	3A	5-8	4
1-31760-NV119	CHECK	GLOBE	MAN	NK29-FXX-31760-0001	4	4A	5-8	4
1-31760-V105	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	2D	5-8	4
1-31760-NV9	CHECK	-0-	-0-	NK29-FXX-31760-0001	4	2A	5-8	4
1-31760-NV120	CHECK	GLOBE	MAN	NK29-FXX-31760-0001	4	4A	5-8	4
1-31760-MV4	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	2A	5-8	4
1-31760-V21	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	5D	5-8	4
1-31760-PRV1	CTRL	GLOBE	SELF	NK29-FXX-31760-0001	4	1A	5-8	4
1-31760-V111	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	3B	5-8	4
1-31760-MV1H	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	3A	5-8	4
1-31760-V22	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	5D	5-8	4
1-31760-MV1J	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	3B	5-8	4
1-31760-V27	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	4D	5-8	4
1-31760-V10	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	2A	5-8	4
1-31760-V117	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-NV52	CHECK	-0-	-0-	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-V47	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	2A	5-8	4
1-31760-MV29	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	5B	5-8	4
1-31760-V112	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	5B	5-8	4
1-31760-NV54	CHECK	-0-	-0-	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-V16	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	3B	5-8	4
1-31760-V101	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	5D	5-8	4
1-31760-V28	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	4D	5-8	4
1-31760-MV3J	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-V18	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-V107	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	4D	5-8	4
1-31760-V23	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	3D	5-8	4
1-31760-NV121	CHECK	GLOBE	MAN	NK29-FXX-31760-0001	4	4A	5-8	4
1-31760-V26	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	3D	5-8	4
1-31760-V103	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	3D	5-8	4
1-31760-RV5	PRV	-0-	-0-	NK29-FXX-31760-0001	4	2A	5-8	4
1-31760-MV2J	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	4A	5-8	4
1-31760-V20	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	5B	5-8	4
1-31760-MV3G	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	3A	5-8	4
1-31760-V24	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	3D	5-8	4
1-31760-MV1G	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	3A	5-8	4
1-31760-V15	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	2B	5-8	4
1-31760-V108	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	5D	5-8	4
1-31760-V25	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	2D	5-8	4
1-31760-V115	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	2B	5-8	4
1-31760-V114	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	3B	5-8	4
1-31760-V14	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	2B	5-8	4
1-31760-V12	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-V13	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	3B	5-8	4
1-31760-V113	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	3B	5-8	4
1-31760-MV2H	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-RV6	PRV	-0-	-0-	NK29-FXX-31760-0001	4	2A	5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

BRUCE B - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-31760-V102	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	5D	5-8	4
1-31760-V116	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	3B	5-8	4
1-31760-V104	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	3D	5-8	4
1-31760-V17	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-V11	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	5B	5-8	4
1-31760-V118	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-V106	ISOL	BALL	MAN	NK29-FXX-31760-0001	4	4D	5-8	4
1-31760-V51	ISOL	GLOBE	MAN	NK29-FXX-31760-0001	4	2A	5-8	4
1-31760-MV3H	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	4B	5-8	4
1-31760-MV2G	ISOL	GLOBE	AIR	NK29-FXX-31760-0001	4	4A	5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

GENTILLY - CONTAINMENT SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
73140-PV9	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV3	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV22	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
34310-PV11	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV11	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV15	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV5	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV29	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV6	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV14	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV6	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV10	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV5	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV13	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV4	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV30	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV24	-0-	BALL	AIR	87-73140-2001-01-FS-F			1
73140-PV31	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV12	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV1	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV8	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV32	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV16	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV12	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV37	-0-	BALL	AIR	87-73140-2001-01-FS-F			1
73140-SV33N	-0-	GATE	MOV	87-73140-2001-01-FS-F			1
73140-PV7	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-SV34Q	-0-	GATE	MOV	87-73140-2001-01-FS-F			1
73140-PV20	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
34310-PV9	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
34310-PV7	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV2	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV17	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
34310-PV3	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV8	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV4	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV19	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
34310-PV2	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV10	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV18	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
73140-PV21	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
34310-PV1	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

GENTILLY - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34320-RV133	PRV	-0-	-0-	87-34320-2001-01-FS-	9	4C	1	1
1-34320-V134	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	1E	1	1
1-34320-MV66	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	5E	1	1
1-34320-MV79	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-V135	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	2E	1	1
1-34320-V103	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	4C	1	1
1-34320-V136	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	1E	1	1
1-34320-V104	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	4C	1	1
1-34320-V139	CHECK	-0-	MAN	87-34320-2001-01-FS-	9	2D	1	1
1-34320-PV33	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	1D	1	1
1-34320-PV10	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5D	1	1
1-34320-MV75	ISOL	BUTT	MOV	87-34320-2001-01-FS-	9	5C	1	1
1-34320-V099	ISOL	GATE	MAN	87-34320-2001-01-FS-	9	5D	1	1
1-34320-V4	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3E	1	1
1-34320-MV45	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3E	1	1
1-34320-PV11	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5D	1	1
1-34320-V98	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3A	1	1
1-34320-V124	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	3C	1	1
1-34320-PV74	CTRL	GLOBE	AIR	87-34320-2001-02-FS-	3	5B	1	1
1-34320-V140	ISOL	BALL	MAN	87-34320-2001-01-FS-	9	3B	1	1
1-34320-V096	CHECK	GATE	MAN	87-34320-2001-02-FS-	3	3C	1	1
1-34320-RV86	PRV	-0-	-0-	87-34320-2001-01-FS-	9	2C	1	1
1-34320-MV42	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-V111	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	2A	1	1
1-34320-V097	CHECK	GATE	MAN	87-34320-2001-02-FS-	3	3C	1	1
1-34320-PV9	CTRL	BUTT	AIR	87-34320-2001-02-FS-	3	3B	1	1
1-34320-PV73	CTRL	GLOBE	AIR	87-34320-2001-02-FS-	3	2B	1	1
1-34320-MV50	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-PV23	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	4D	1	1
1-34320-V106	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	4C	1	1
1-34320-MV80	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-RV85	PRV	-0-	-0-	87-34320-2001-01-FS-	9	4B	1	1
1-34320-V113	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3A	1	1
1-34320-PV47	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	4E	1	1
1-34320-V174	PRV	-0-	-0-	87-34320-2001-02-FS-	3	2A	1	1
1-34320-MV72	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-PV83	CTRL	GLOBE	AIR	87-34320-2001-01-FS-	9	3B	1	1
1-34320-V105	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	4C	1	1
1-34320-PV82	CTRL	BALL	AIR	87-34320-2001-01-FS-	9	2C	1	1
1-34320-MV62	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	5E	1	1
1-34320-V076	CHECK	-0-	MAN	87-34320-2001-02-FS-	3	3B	1	1
1-34320-V5	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	3E	1	1
1-34320-PV84	CTRL	GLOBE	AIR	87-34320-2001-01-FS-	9	3B	1	1
1-34320-V144	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	3C	1	1
1-34320-MV71	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-V143	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	3B	1	1
1-34320-MV31	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3B	1	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

GENTILLY - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34320-V15	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	2C	1	1
1-34320-V077	CHECK	-0-	MAN	87-34320-2001-02-FS-	3	3C	1	1
1-34320-PV81	CTRL	BALL	AIR	87-34320-2001-01-FS-	9	3B	1	1
1-34320-MV63	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	6E	1	1
1-34320-PV2	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5E	1	1
1-34320-RV26	PRV	-0-	-0-	87-34320-2001-01-FS-	9	1E	1	1
1-34320-RV102	PRV	-0-	-0-	87-34320-2001-01-FS-	9	3B	1	1
1-34320-MV64	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	6E	1	1
1-34320-MV59	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	4E	1	1
1-34320-MV65	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	5E	1	1
1-34320-V3	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3E	1	1
1-34320-MV61	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	4E	1	1
1-34320-MV44	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	2E	1	1
1-34320-MV60	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	4E	1	1
1-34320-PV1	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5E	1	1
1-34320-PV78	CTRL	GATE	AIR	87-34320-2001-02-FS-	3	2B	1	1
1-34320-V6	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	3E	1	1
1-34320-MV46	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3E	1	1
1-34320-V141	ISOL	BALL	MAN	87-34320-2001-01-FS-	9	2B	1	1
1-34320-MV43	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	2E	1	1
1-34320-PV48	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	5D	1	1
1-34320-MV39	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-V101	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	2A	1	1
1-34320-MV40	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-V107	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	5C	1	1
1-34320-MV41	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-V110	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	4C	1	1
1-34320-V121	ISOL	GATE	MAN	87-34320-2001-02-FS-	3	4B	1	1
1-34320-PV8	CTRL	BUTT	AIR	87-34320-2001-02-FS-	3	3C	1	1
1-34320-V175	PRV	-0-	-0-	87-34320-2001-02-FS-	3	5A	1	1
1-34320-V119	ISOL	GATE	MAN	87-34320-2001-02-FS-	3	1B	1	1
1-34320-V176	PRV	-0-	-0-	87-34320-2001-02-FS-	3	2A	1	1
1-34320-V142	ISOL	BALL	MAN	87-34320-2001-01-FS-	9	2C	1	1
1-34320-V118	ISOL	GATE	MAN	87-34320-2001-01-FS-	9	3D	1	1
1-34320-V123	ISOL	GATE	MAN	87-34320-2001-01-FS-	9	2B	1	1
1-34320-PV34	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	2D	1	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

GENTILLY - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
1-34700-V101	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-V138	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	4B	1
1-34700-V10	ISOL	-0-	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-V116	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5B	1
1-34700-V132	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-V215	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4C	1
1-34700-V225	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	1A	1
1-34700-V140	CHECK	-0-	AIR	87-34700-2001-01-FS-	7	3B	1
1-34700-V226	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-PV3J	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1
1-34700-PRV7#1	CTRL	-0-	SELF	87-34700-2001-01-FS-	7	1A	1
1-34700-V214	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3C	1
1-34700-V227	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	1A	1
1-34700-V24	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-V228	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-PV1H	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3A	1
1-34700-V9	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	2A	1
1-34700-V25	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4D	1
1-34700-V33	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-PV30	ISOL	GLOBE	AIR	87-34700-2001-01-FS-	7	2B	1
1-34700-PV55	ISOL	-0-	-0-	87-34700-2001-01-FS-	7	6B	1
1-34700-V211	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3C	1
1-34700-V21	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-V111	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-V114	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-V133	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5B	1
1-34700-V231	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-V115	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-V104	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-RV6	PRV	-0-	-0-	87-34700-2001-01-FS-	7	3A	1
1-34700-V134	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-V113	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5B	1
1-34700-V8	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3A	1
1-34700-PRV7#2	CTRL	-0-	SELF	87-34700-2001-01-FS-	7	2A	1
1-34700-V232	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2B	1
1-34700-V112	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-V131	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2B	1
1-34700-V212	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4C	1
1-34700-PV3H	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1
1-34700-PV2H	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4B	1
1-34700-NV217	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	2C	1
1-34700-PV4	ISOL	GLOBE	AIR	87-34700-2001-01-FS-	7	2A	1
1-34700-V47	ISOL	-0-	MAN	87-34700-2001-01-FS-	7	3A	1
1-34700-V26	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-V103	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-RV5	PRV	-0-	-0-	87-34700-2001-01-FS-	7	2A	1
1-34700-PV2G	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

GENTILLY - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
1-34700-V139	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	4B	1
1-34700-V20	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	2B	1
1-34700-V135	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-V245	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-PV1G	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3A	1
1-34700-V106	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-V216	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5C	1
1-34700-V243	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-V213	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5C	1
1-34700-V22	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4D	1
1-34700-PV3G	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3A	1
1-34700-V244	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-PV1J	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3B	1
1-34700-V23	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-V136	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-PV2J	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1
1-34700-V102	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4D	1
1-34700-V105	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4D	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING A - CONTAINMENT SYSTEM*

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R GRID UNITS	NO. OF VALVES
34220-MV5	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV29	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV1	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV31	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV79	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34210-PRV3	PRV	-0-	SELF	RMEP-IR-03600-46		1
34210-PRV12	PRV	-0-	SELF	RMEP-IR-03600-46		1
34220-MV3	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV81	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV47	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34210-PRV11	PRV	-0-	SELF	RMEP-IR-03600-46		1
34220-MV48	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34210-PRV5	PRV	-0-	SELF	RMEP-IR-03600-46		1
34210-PRV6	PRV	-0-	SELF	RMEP-IR-03600-46		1
34210-PRV1	PRV	-0-	SELF	RMEP-IR-03600-46		1
34220-MV46	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV7	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34230-MV105	ISOL	-0-	MOV	RMEP-IR-03600-46		1
34230-MV112	ISOL	-0-	MOV	RMEP-IR-03600-46		1
34210-PRV9	PRV	-0-	SELF	RMEP-IR-03600-46		1
34210-PRV2	PRV	-0-	SELF	RMEP-IR-03600-46		1
34210-PRV4	PRV	-0-	SELF	RMEP-IR-03600-46		1
34230-MV111	ISOL	-0-	MOV	RMEP-IR-03600-46		1
34210-PRV10	PRV	-0-	SELF	RMEP-IR-03600-46		1
34220-MV9	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34220-MV30	ISOL	-0-	AIR	RMEP-IR-03600-46		1
34210-PRV7	PRV	-0-	SELF	RMEP-IR-03600-46		1
34210-PRV8	PRV	-0-	SELF	RMEP-IR-03600-46		1
34230-MV106	ISOL	-0-	MOV	RMEP-IR-03600-46		1

* Pickering 'A' and Pickering 'B' stations share a single vacuum building and related equipment. There may be some duplication between valves listed for Pickering 'A' and those listed on page B-1-22 for Pickering 'B'. It was not possible to tell from the sources reviewed where the overlap occurs. The effect on the analysis should not be significant.

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING A - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-33350-NV455	CHECK	-0-	-0-	44-1-0-33350-FS-1	4	3D	1 - 4	4
1-33350-NV470	CHECK	-0-	-0-	44-1-0-33350-FS-1	4	4C	1 - 4	4
1-33350-V477	ISOL	-0-	MAN	44-1-0-33350-FS-1	4	4C	1 - 4	4
1-33350-MV471	ISOL	-0-	-0-	44-1-0-33350-FS-1	4	4C	1 - 4	4
1-33350-NV454	CHECK	-0-	-0-	44-1-0-33350-FS-1	4	5D	1 - 4	4
1-33350-NV453	CHECK	BUTT	-0-	44-1-0-33350-FS-1	4	2D	1 - 4	4
1-33350-NV452	CHECK	-0-	-0-	44-1-0-33350-FS-1	4	6C	1 - 4	4
1-33350-CV450	CTRL	-0-	AIR	44-1-0-33350-FS-1	4	4C	1 - 4	4
1-33350-NV451	CHECK	-0-	-0-	44-1-0-33350-FS-1	4	4C	1 - 4	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING B - CONTAINMENT SYSTEM *

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R GRID UNITS	NO. OF VALVES
34210-PRV9	PRV	-0-	SELF	RMEP-IR-03624-7		1
34210-PRV7	PRV	-0-	SELF	RMEP-IR-03624-7		1
34960-MV306	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34210-PRV2	PRV	-0-	SELF	RMEP-IR-03624-7		1
34230-MV103	ISOL	-0-	MOV	RMEP-IR-03624-7		1
34210-PRV5	PRV	-0-	SELF	RMEP-IR-03624-7		1
34960-MV317	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34210-PRV4	PRV	-0-	SELF	RMEP-IR-03624-7		1
34230-MV113	ISOL	-0-	MOV	RMEP-IR-03624-7		1
34960-MV312	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34230-MV112	ISOL	-0-	MOV	RMEP-IR-03624-7		1
34220-MV1	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34230-MV108	ISOL	-0-	MOV	RMEP-IR-03624-7		1
34220-MV9	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34230-MV106	ISOL	-0-	MOV	RMEP-IR-03624-7		1
34220-MV48	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34960-MV309	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34210-PRV11	PRV	-0-	SELF	RMEP-IR-03624-7		1
34960-MV307	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34210-PRV10	PRV	-0-	SELF	RMEP-IR-03624-7		1
34220-MV3	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34220-MV47	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34220-MV81	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34220-MV46	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34220-MV7	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34220-MV79	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34960-MV314	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34210-PRV1	PRV	-0-	SELF	RMEP-IR-03624-7		1
34230-MV107	ISOL	-0-	MOV	RMEP-IR-03624-7		1
34220-MV31	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34230-MV104	ISOL	BUTT	MOV	RMEP-IR-03624-7		1
34220-MV30	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34210-PRV6	PRV	-0-	SELF	RMEP-IR-03624-7		1
34210-PRV12	PRV	-0-	SELF	RMEP-IR-03624-7		1
34960-MV315	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34210-PRV3	PRV	-0-	SELF	RMEP-IR-03624-7		1
34230-MV105	ISOL	-0-	MOV	RMEP-IR-03624-7		1
21103-MV2	ISOL	-0-	AIR	RMEP-IR-03624-7		1
21103-MV1	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34220-MV5	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34960-MV311	ISOL	-0-	AIR	RMEP-IR-03624-7		1
34220-MV29	ISOL	-0-	AIR	RMEP-IR-03624-7		1

* Pickering 'A' and Pickering 'B' stations share a single vacuum building and related equipment. There may be some duplication between valves listed for Pickering 'B' and those listed for Pickering 'A'. It was not possible to tell from the sources reviewed where the overlap occurs. The effect on the analysis should not be significant.

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING B - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-33350-MV35	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	4A	5-8	4
1-33350-RV271	PRV	-0-	-0-	30-58-0-33350-FS-1	0	4A	0	1
1-33350-V1	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	3B	56-78	2
1-33350-CV321	CTRL	-0-	AIR	30-56-0-33350-FS-1	3	8D	5 - 8	4
1-33350-V304	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	1B	0	1
1-33350-NV203	CHECK	-0-	-0-	30-56-0-33350-FS-1	3	3E	56-78	2
1-33350-MNV174	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	2D	0	1
1-33350-MV202	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	4E	56-78	2
1-33350-MV40	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	2A	5-8	4
1-33350-MV55	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	4D	5-8	4
1-33350-V197	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	6D	0	1
1-33350-V196	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	8D	0	1
1-33350-V194	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	8D	0	1
1-33350-NV3	CHECK	-0-	-0-	30-56-0-33350-FS-1	3	4B	56-78	2
1-33350-MNV191	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	7C	0	1
1-33350-RV248	PRV	-0-	-0-	30-58-0-33350-FS-1	0	4D	0	1
1-33350-V212	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	6C	0	1
1-33350-CV246	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	1B	0	1
1-33350-MV46	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	2B	5-8	4
1-33350-MV59	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	1D	5-8	4
1-33350-V169	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	4A	0	1
1-33350-MV160	ISOL	-0-	-0-	30-58-0-33350-FS-1	0	4C	0	1
1-33350-V6	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	4C	56-78	2
1-33350-V305	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	2E	56-78	2
1-33350-V310	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	6D	0	1
1-33350-RV272	PRV	-0-	-0-	30-58-0-33350-FS-1	0	4A	0	1
1-33350-MV175	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	3E	0	1
1-33350-V16	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	3A	56-78	2
1-33350-RV231	PRV	-0-	-0-	30-60-0-33350-FS-1	2	4D	5 - 8	4
1-33350-CV295	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	1B	0	1
1-33350-MV152	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	4E	0	1
1-33350-CV301	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	7D	0	1
1-33350-MV201	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	4E	56-78	2
1-33350-MV39	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	1A	5-8	4
1-33350-V184	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	2B	0	1
1-33350-CV320	CTRL	-0-	AIR	30-56-0-33350-FS-1	3	8D	5 - 8	4
1-33350-V303	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	1A	0	1
1-33350-CV302	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	6D	0	1
1-33350-V2	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	3C	56-78	2
1-33350-MV70	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	2D	5-8	4
1-33350-V166	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	2E	0	1
1-33350-V289	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	6C	0	1
1-33350-MNV190	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	6C	0	1
1-33350-V162	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	2C	0	1
1-33350-NV17	CHECK	-0-	-0-	30-56-0-33350-FS-1	3	4A	56-78	2
1-33350-RV228	PRV	-0-	-0-	30-60-0-33350-FS-1	2	7D	5 - 8	4
1-33350-MV114	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	5C	56-78	2

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING B - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-33350-MV48	CHECK	-0-	-0-	30-6-0-33350-FS-1	2	4D	5-8	4
1-33350-V164	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	2D	0	1
1-33350-MV36	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	4B	5-8	4
1-33350-MV54	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	4D	5-8	4
1-33350-MV65	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	3D	5-8	4
1-33350-RV229	PRV	-0-	-0-	30-60-0-33350-FS-1	2	3A	5 - 8	4
1-33350-MV155	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	7E	5-8	4
1-33350-V161	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	4C	0	1
1-33350-V322	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	8D	5 - 8	4
1-33350-RV340	PRV	-0-	-0-	30-60-0-33350-FS-1	2	6C	5 - 8	4
1-33350-V306	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	2E	56-78	2
1-33350-V165	ISOL	-0-	-0-	30-58-0-33350-FS-1	0	4E	0	1
1-33350-MV34	CHECK	-0-	-0-	30-6-0-33350-FS-1	2	4B	5-8	4
1-33350-V163	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	4D	0	1
1-33350-MNV193	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	7D	0	1
1-33350-MV62	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	2D	5-8	4
1-33350-RV341	PRV	-0-	-0-	30-60-0-33350-FS-1	2	6D	5 - 8	4
1-33350-V28	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	7C	56-78	2
1-33350-CV297	CTRL	-0-	AIR	30-56-0-33350-FS-1	3	2E	56-78	2
1-33350-MV64	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	2D	5-8	4
1-33350-MV156	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	6C	5-8	4
1-33350-RV227	PRV	-0-	-0-	30-60-0-33350-FS-1	2	7C	5 - 8	4
1-33350-MNV192	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	6D	0	1
1-33350-MV176	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	2E	0	1
1-33350-MV109	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	3D	5-8	4
1-33350-NV33	CHECK	-0-	-0-	30-6-0-33350-FS-1	2		5-8	4
1-33350-V183	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	4B	0	1
1-33350-MV45	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	3B	5-8	4
1-33350-MV23	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	6E	56-78	2
1-33350-MV153	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	4E	0	1
1-33350-V309	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	7D	0	1
1-33350-NV47	CHECK	-0-	-0-	30-6-0-33350-FS-1	2	5E	5-8	4
1-33350-V168	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	2A	0	1
1-33350-CV298	CTRL	-0-	AIR	30-56-0-33350-FS-1	3	2E	56-78	2
1-33350-CV179	-0-	-0-	-0-	30-58-0-33350-FS-1	0	3A	0	1
1-33350-V5	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	4B	56-78	2
1-33350-MV157	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	6E	5-8	4
1-33350-V129	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	2E	5-8	4
1-33350-MNV171	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	3C	0	1
1-33350-V198	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	5C	0	1
1-33350-MV158	CHECK	-0-	-0-	30-6-0-33350-FS-1	2	6C	5-8	4
1-33350-MV60	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	1D	5-8	4
1-33350-V18	ISOL	-0-	MAN	30-56-0-33350-FS-1	3	4A	56-78	2
1-33350-MV339	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	5C	5-8	4
1-33350-CV180	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	3A	0	1
1-33350-MNV172	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	2C	0	1
1-33350-MV71	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	3D	5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING B - ECI SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-33350-MV43	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	3B	5-8	4
1-33350-V170	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	2A	0	1
1-33350-MV44	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	2B	5-8	4
1-33350-MV42	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	1A	5-8	4
1-33350-V281	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	2B	0	1
1-33350-RV230	PRV	-0-	-0-	30-60-0-33350-FS-1	2	4B	5 - 8	4
1-33350-MV41	ISOL	BUTT	MOV	30-6-0-33350-FS-1	2	1A	5-8	4
1-33350-MV154	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	7C	5-8	4
1-33350-MV7	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	7C	56-78	2
1-33350-NV4	CHECK	SWING	-0-	30-56-0-33350-FS-1	3	4C	56-78	2
1-33350-MV151	ISOL	-0-	-0-	30-58-0-33350-FS-1	0	5E	0	1
1-33350-CV177	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	3A	0	1
1-33350-MV338	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	5C	5-8	4
1-33350-RV232	PRV	-0-	-0-	30-60-0-33350-FS-1	2	4D	5 - 8	4
1-33350-MNV173	CHECK	-0-	-0-	30-58-0-33350-FS-1	0	3D	0	1
1-33350-CV178	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	3A	0	1
1-33350-MV110	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	6E	56-78	2
1-33350-NV159	CHECK	-0-	-0-	30-6-0-33350-FS-1	2	6E	5-8	4
1-33350-MV66	ISOL	BUTT	MOV	30-6-0-33350-FS-1	2	2D	5-8	4
1-33350-CV182	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	3B	0	1
1-33350-MV63	ISOL	-0-	-0-	30-6-0-33350-FS-1	2	3D	5-8	4
1-33350-MV115	ISOL	-0-	-0-	30-56-0-33350-FS-1	3	5B	56-78	2
1-33350-V195	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	8D	0	1
1-33350-V167	ISOL	-0-	MAN	30-58-0-33350-FS-1	0	4A	0	1
1-33350-MV61	ISOL	BUTT	MOV	30-6-0-33350-FS-1	2	1D	5-8	4
1-33350-CV181	CTRL	-0-	AIR	30-58-0-33350-FS-1	0	4B	0	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING B - SDS2

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34700-MV55	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	6B	5-8	4
1-34700-V134	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4B	5-8	4
1-34700-V113	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	2B	5-8	4
1-34700-V25	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4D	5-8	4
1-34700-MV2J	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	5A	5-8	4
1-34700-V101	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	6D	5-8	4
1-34700-MV2H	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	5B	5-8	4
1-34700-V136	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	3B	5-8	4
1-34700-V115	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3B	5-8	4
1-34700-V114	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	5B	5-8	4
1-34700-V133	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	2B	5-8	4
1-34700-NV13	CHECK	-0-	-0-	30-5-0-34700-FS-1	3	4B	5-8	4
1-34700-MV2G	ISOL	GLOBE	AIR	30-5-0-34700-FS-1	3	5A	5-8	4
1-34700-MV3G	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	4A	5-8	4
1-34700-V8	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3A	5-8	4
1-34700-NV14	CHECK	-0-	-0-	30-5-0-34700-FS-1	3	4B	5-8	4
1-34700-V132	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4B	5-8	4
1-34700-V214	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	5C	5-8	4
1-34700-V211	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	6C	5-8	4
1-34700-V106	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3D	5-8	4
1-34700-V56	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	6B	5-8	4
1-34700-V135	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3B	5-8	4
1-34700-V22	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4D	5-8	4
1-34700-V105	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4D	5-8	4
1-34700-V111	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	5C	5-8	4
1-34700-V102	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4D	5-8	4
1-34700-V53	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	5B	5-8	4
1-34700-V104	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	5D	5-8	4
1-34700-V213	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	2C	5-8	4
1-34700-NV15	CHECK	-0-	-0-	30-5-0-34700-FS-1	3	4B	5-8	4
1-34700-MV1H	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	4A	5-8	4
1-34700-V12	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	2A	5-8	4
1-34700-RV5	PRV	-0-	-0-	30-5-0-34700-FS-1	3	2A	5-8	4
1-34700-V216	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3C	5-8	4
1-34700-MV1J	ISOL	GLOBE	AIR	30-5-0-34700-FS-1	3	4B	5-8	4
1-34700-V103	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	2D	5-8	4
1-34700-V201	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	2D	5-8	4
1-34700-NV9	CHECK	-0-	-0-	30-5-0-34700-FS-1	3	2A	5-8	4
1-34700-V24	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	5D	5-8	4
1-34700-NV54	CHECK	-0-	-0-	30-5-0-34700-FS-1	3	5B	5-8	4
1-34700-V26	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3D	5-8	4
1-34700-V116	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3B	5-8	4
1-34700-V215	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4C	5-8	4
1-34700-PRV7	CTRL	GLOBE	SELF	30-5-0-34700-FS-1	3	2A	5-8	4
1-34700-V23	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	2D	5-8	4
1-34700-MV1G	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	4A	5-8	4
1-34700-V21	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	6D	5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

PICKERING B - SDS2

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VALVES
1-34700-MV4	ISOL	-0-	-0-	30-5-0-34700-FS-1	3	2A	5-8	4
1-34700-V47	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	3A	5-8	4
1-34700-NV217	CHECK	-0-	-0-	30-5-0-34700-FS-1	3	2D	5-8	4
1-34700-V112	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4B	5-8	4
1-34700-V212	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	4C	5-8	4
1-34700-V131	ISOL	-0-	MAN	30-5-0-34700-FS-1	3	5C	5-8	4
1-34700-RV6	PRV	-0-	-0-	30-5-0-34700-FS-1	3	3A	5-8	4

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

POINT LEPREAU - CONTAINMENT SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
34310-PV6	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
34310-PV11	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV22	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
73140-PV20	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
34310-PV5	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV21	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
73140-PV30	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV4	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV19	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
73140-PV17	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
73140-PV2	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV16	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV32	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV4	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV37	-0-	BALL	AIR	87-73140-2001-01-FS-F			1
73140-PV1	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV12	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV15	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV18	-0-	DIA	AIR	87-73140-2001-01-FS-F			1
73140-PV29	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV8	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV5	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV7	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV6	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV10	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV14	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-SV33N	-0-	GATE	MOV	87-73140-2001-01-FS-F			1
73140-PV24	-0-	BALL	AIR	87-73140-2001-01-FS-F			1
34310-PV3	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV13	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV10	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV7	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV1	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV12	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-SV34Q	-0-	GATE	MOV	87-73140-2001-01-FS-F			1
73140-PV8	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV2	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV11	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV3	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
34310-PV9	-0-	BUTT	AIR	87-34310-2001-01-FS-F			1
73140-PV31	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1
73140-PV9	-0-	BUTT	AIR	87-73140-2001-01-FS-F			1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

POINT LEPREAU - ECC SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VAL
1-34320-V119	ISOL	GATE	MAN	87-34320-2001-02-FS-	3	1B	1	1
1-34320-V106	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	4C	1	1
1-34320-PV73	CTRL	GLOBE	AIR	87-34320-2001-02-FS-	3	2B	1	1
1-34320-MV72	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-MV59	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	4E	1	1
1-34320-MV42	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-V134	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	1E	1	1
1-34320-V141	ISOL	BALL	MAN	87-34320-2001-01-FS-	9	2B	1	1
1-34320-V101	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	2A	1	1
1-34320-MV65	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	5E	1	1
1-34320-PV34	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	2D	1	1
1-34320-RV133	PRV	-0-	-0-	87-34320-2001-01-FS-	9	4C	1	1
1-34320-V105	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	4C	1	1
1-34320-MV43	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	2E	1	1
1-34320-V077	CHECK	-0-	MAN	87-34320-2001-02-FS-	3	3C	1	1
1-34320-V143	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	3B	1	1
1-34320-V104	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	4C	1	1
1-34320-V103	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	4C	1	1
1-34320-V110	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	4C	1	1
1-34320-RV26	PRV	-0-	-0-	87-34320-2001-01-FS-	9	1E	1	1
1-34320-MV62	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	5E	1	1
1-34320-V175	PRV	-0-	-0-	87-34320-2001-02-FS-	3	5A	1	1
1-34320-MV31	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3B	1	1
1-34320-PV48	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	5D	1	1
1-34320-MV63	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	6E	1	1
1-34320-PV8	CTRL	BUTT	AIR	87-34320-2001-02-FS-	3	3C	1	1
1-34320-PV33	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	1D	1	1
1-34320-V124	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	3C	1	1
1-34320-V15	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	2C	1	1
1-34320-PV11	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5D	1	1
1-34320-V118	ISOL	GATE	MAN	87-34320-2001-01-FS-	9	3D	1	1
1-34320-PV82	CTRL	BALL	AIR	87-34320-2001-01-FS-	9	2C	1	1
1-34320-PV74	CTRL	GLOBE	AIR	87-34320-2001-02-FS-	3	5B	1	1
1-34320-MV45	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3E	1	1
1-34320-V099	ISOL	GATE	MAN	87-34320-2001-01-FS-	9	5D	1	1
1-34320-MV79	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-PV78	CTRL	GATE	AIR	87-34320-2001-02-FS-	3	2B	1	1
1-34320-V176	PRV	-0-	-0-	87-34320-2001-02-FS-	3	2A	1	1
1-34320-V107	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	5C	1	1
1-34320-V123	ISOL	GATE	MAN	87-34320-2001-01-FS-	9	2B	1	1
1-34320-V6	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	3E	1	1
1-34320-MV71	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-V142	ISOL	BALL	MAN	87-34320-2001-01-FS-	9	2C	1	1
1-34320-MV44	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	2E	1	1
1-34320-V140	ISOL	BALL	MAN	87-34320-2001-01-FS-	9	3B	1	1
1-34320-MV50	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

POINT LEPREAU - ECC SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID	UNITS	NO. OF VAL
1-34320-V135	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	2E	1	1
1-34320-MV60	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	4E	1	1
1-34320-V139	CHECK	-0-	MAN	87-34320-2001-01-FS-	9	2D	1	1
1-34320-MV40	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-V096	CHECK	GATE	MAN	87-34320-2001-02-FS-	3	3C	1	1
1-34320-RV102	PRV	-0-	-0-	87-34320-2001-01-FS-	9	3B	1	1
1-34320-PV10	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5D	1	1
1-34320-MV41	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-V076	CHECK	-0-	MAN	87-34320-2001-02-FS-	3	3B	1	1
1-34320-MV46	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3E	1	1
1-34320-PV84	CTRL	GLOBE	AIR	87-34320-2001-01-FS-	9	3B	1	1
1-34320-MV75	ISOL	BUTT	MOV	87-34320-2001-01-FS-	9	5C	1	1
1-34320-V121	ISOL	GATE	MAN	87-34320-2001-02-FS-	3	4B	1	1
1-34320-PV83	CTRL	GLOBE	AIR	87-34320-2001-01-FS-	9	3B	1	1
1-34320-V144	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	3C	1	1
1-34320-PV81	CTRL	BALL	AIR	87-34320-2001-01-FS-	9	3B	1	1
1-34320-V113	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3A	1	1
1-34320-V111	ISOL	GLOBE	MAN	87-34320-2001-01-FS-	9	2A	1	1
1-34320-V5	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	3E	1	1
1-34320-V4	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3E	1	1
1-34320-V136	ISOL	BUTT	MAN	87-34320-2001-01-FS-	9	1E	1	1
1-34320-MV61	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	4E	1	1
1-34320-PV1	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5E	1	1
1-34320-RV86	PRV	-0-	-0-	87-34320-2001-01-FS-	9	2C	1	1
1-34320-MV66	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	5E	1	1
1-34320-MV64	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	6E	1	1
1-34320-V097	CHECK	GATE	MAN	87-34320-2001-02-FS-	3	3C	1	1
1-34320-PV47	CHECK	-0-	-0-	87-34320-2001-02-FS-	3	4E	1	1
1-34320-PV23	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	4D	1	1
1-34320-V3	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3E	1	1
1-34320-RV85	PRV	-0-	-0-	87-34320-2001-01-FS-	9	4B	1	1
1-34320-PV2	CTRL	BUTT	AIR	87-34320-2001-01-FS-	9	5E	1	1
1-34320-PV9	CTRL	BUTT	AIR	87-34320-2001-02-FS-	3	3B	1	1
1-34320-MV39	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	1E	1	1
1-34320-MV80	ISOL	GATE	MOV	87-34320-2001-02-FS-	3	3C	1	1
1-34320-V174	PRV	-0-	-0-	87-34320-2001-02-FS-	3	2A	1	1
1-34320-V98	CHECK	-0-	-0-	87-34320-2001-01-FS-	9	3A	1	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

POINT LEPREAU - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
1-34700-PV2J	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1
1-34700-NV217	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	2C	1
1-34700-V133	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5B	1
1-34700-V139	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	4B	1
1-34700-V135	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-V216	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5C	1
1-34700-V134	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-V215	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4C	1
1-34700-V211	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3C	1
1-34700-PRV7#1	CTRL	-0-	SELF	87-34700-2001-01-FS-	7	1A	1
1-34700-V20	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	2B	1
1-34700-PRV7#2	CTRL	-0-	SELF	87-34700-2001-01-FS-	7	2A	1
1-34700-V213	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5C	1
1-34700-V138	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	4B	1
1-34700-V21	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-V103	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-V22	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4D	1
1-34700-PV1G	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3A	1
1-34700-V26	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-PV30	ISOL	GLOBE	AIR	87-34700-2001-01-FS-	7	2B	1
1-34700-V111	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-RV5	PRV	-0-	-0-	87-34700-2001-01-FS-	7	2A	1
1-34700-V112	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-RV6	PRV	-0-	-0-	87-34700-2001-01-FS-	7	3A	1
1-34700-V116	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5B	1
1-34700-V9	CHECK	-0-	-0-	87-34700-2001-01-FS-	7	2A	1
1-34700-V101	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-PV3G	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3A	1
1-34700-V102	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4D	1
1-34700-PV3H	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1
1-34700-V244	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-PV2H	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4B	1
1-34700-V243	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-PV1H	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3A	1
1-34700-V136	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-V140	CHECK	-0-	AIR	87-34700-2001-01-FS-	7	3B	1
1-34700-V131	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2B	1
1-34700-PV3J	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1
1-34700-V212	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4C	1
1-34700-PV4	ISOL	GLOBE	AIR	87-34700-2001-01-FS-	7	2A	1
1-34700-V24	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-PV1J	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	3B	1
1-34700-V23	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-V225	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	1A	1
1-34700-V115	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4B	1
1-34700-V226	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	2A	1

PROJECT 414 - AECB VALVE POPULATION DATA BASE PART 1

POINT LEPREAU - SDS2 SYSTEM

U-USI-CODE	FUNCTION	TYPE	ACTUATOR	FLOWSHEET	R	GRID UNITS	NO. OF VALVES
1-34700-V104	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3D	1
1-34700-V227	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	1A	1
1-34700-V106	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5D	1
1-34700-V228	ISOL	NEEDLE	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-V132	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-PV2G	ISOL	-0-	AIR	87-34700-2001-01-FS-	7	4A	1
1-34700-V245	ISOL	GATE	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-V33	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-V114	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	3B	1
1-34700-V231	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-V105	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	4D	1
1-34700-V8	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3A	1
1-34700-V214	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	3C	1
1-34700-V232	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	2B	1
1-34700-V113	ISOL	BALL	MAN	87-34700-2001-01-FS-	7	5B	1
1-34700-V25	ISOL	GLOBE	MAN	87-34700-2001-01-FS-	7	4D	1
1-34700-PV55	ISOL	-0-	-0-	87-34700-2001-01-FS-	7	6B	1
1-34700-V10	ISOL	-0-	MAN	87-34700-2001-01-FS-	7	2A	1
1-34700-V47	ISOL	-0-	MAN	87-34700-2001-01-FS-	7	3A	1
							1995

PART II - FAILURE POPULATION

LEAD SHEET

DESCRIPTION:	Valve failure events by date/site/unit as extracted from SER's and QTR's 1982-1986.
SYSTEMS:	ECC, SDS2, CONT.
SITES:	Pickering A, Pickering B, Bruce A, Bruce B

COLUMN HEADINGS	CONTENTS
SRC (SOURCE)	- QTR OR SER
FDATE	- YEAR/MONTH/DAY
PLANT	- P OR B
SITE	- A OR B
UNIT	- O - 8*
USI	- USI NO.
CODE	- COMPONENT CODE
SYSTEM	- ECC, SDS2, CONT.
FUNCTION	- CHECK, CTRL, ISOL, PRV.
TYPE	- BALL, BUTTERFLY, GATE, GLOBE
DISCOVERY	- PROCESS TRANS., TESTING, ALL IDENTICAL, ROUTINE INS, EXL.
FMODE	- EXL, FC, FTC, FO, FTO, FTS, IMPO, ENL, L, SLOW.
ACTUATOR	- AIR, HYD, MAN, MOV, SELF, SOL.
FCAUSE	- MISC. ENTRIES

* Note that zero designates a valve that services all units at its site.

PROJECT 414 - AECB DATA BASE PART 2 - FAILURE POPULATION

SRC	FDATE	SITE	UNIT	USI-CODE	SYS	FUNCTION	TYPE	DISCOVERY	FMODE	ACTUATOR	FCAUSE
QTR	831025	BA	0	CV	CONT	CHK	-0-	?	L	-0-	?
QTR	830818	BA	4	38310MV15	CONT	ISO	-0-	TESTING	L	MOV	RUP DIAPHRAGM
QTR	830818	BA	4	38310MV16	CONT	ISO	-0-	TESTING	L	MOV	RUP DIAPHRAGM
SER	850119	BA	0	34210CV500	CONT	CHK	-0-	TESTING	FTS	-0-	?
QTR	820714	BA	0	38310MV16	CONT	ISO	-0-	?	FTC	MOV	?
QTR	820218	BA	0	38310MV16	CONT	ISO	-0-	TESTING	INL	MOV	RUP DIAPHRAGM
QTR	820714	BA	0	38310MV15	CONT	ISO	-0-	?	FTC	MOV	?
QTR	820218	BA	0	38310MV15	CONT	ISO	-0-	TESTING	L	MOV	RUP DIAPHRAGM
QTR	850722	BA	4	34330MV2	ECI	ISO	GATE	?	L	HYD	?
QTR	860427	BA	0	34340MV324	ECI	ISO	GATE	?	IMOP	HYD	?
SER	830712	BA	1	34330MV14	ECI	ISO	GATE	TESTING	FTO	MOV	BAD TORQUE SWITCH
SER	860617	BA	0	34340MV367	ECI	ISO	BUTT	TESTING	FTO	MOV	BAD LIMIT SWITCH
QTR	830812	BA	3	34330MV15	ECI	ISO	GATE	?	INL	MOV	BAD LIMIT SWITCH
QTR	850103	BA	3	34330MV11	ECI	ISO	GATE	?	INL	-0-	?
SER	861013	BA	4	34330MV15	ECI	ISO	GATE	?	IMOP	MOV	BAD LIMIT SWITCH
SER	860106	BA	0	34340PRV344	ECI	CON	BUTT	TESTING	IMOP	AIR	?
QTR	861107	BA	3	34330MV16	ECI	ISO	GATE	?	INL	HYD	?
QTR	830626	BA	3	34330CV21	ECI	CHK	GATE	?	L	-0-	?
QTR	850722	BA	4	34330MV3	ECI	ISO	GATE	?	L	HYD	?
QTR	860714	BA	0	34340PRV344	ECI	CON	BUTT	?	IMOP	AIR	?
SER	860220	BA	0	34340MV313	ECI	ISO	GATE	?	FTC	HYD	?
QTR	820308	BA	2	34330CV1	ECI	CHK	GATE	?	INL	-0-	FAULTY SEALS
SER	860223	BA	0	34340MV313	ECI	ISO	GATE	TESTING	FTC	HYD	BAD AIR CYCLE VALVE
QTR	860421	BA	0	34340PRV344	ECI	CON	BUTT	?	IMOP	AIR	?
QTR	840212	BA	3	34330MV14	ECI	ISO	GATE	TESTING	FTO	MOV	BAD LIM & TORQ SWs
QTR	830328	BA	2	34330CV1	ECI	CHK	GATE	?	EXL	-0-	LOOSE SHAFT PACKING
SER	820723	BA	3	34330MV14	ECI	ISO	GATE	TESTING	FTS	MOV	BAD TORQUE SWITCH
SER	840322	BA	4	34330MV14	ECI	ISO	GATE	TESTING	FTO	MOV	TESTING DAMAGE
SER	850221	BA	4	34330MV14	ECI	ISO	GATE	TESTING	FTC	MOV	BAD LIMIT SWITCH
QTR	820308	BA	2	34330CV2	ECI	CHK	GATE	?	INL	SELF	FAULTY SEALS
QTR	850401	BA	3	34330MV15	ECI	ISO	GATE	?	INL	MOV	?

PROJECT 414 - AECB DATA BASE PART 2 - FAILURE POPULATION .

SRC	FDATE	SITE	UNIT	USI-CODE	SYS	FUNCTION	TYPE	DISCOVERY	FMODE	ACTUATOR	FCAUSE
SER	860131	BA	3	34330MV14	ECI	ISO	GATE	TESTING	FTO	MOV	BAD LIMIT SWITCH
SER	860617	BA	0	34340MV114	ECI	ISO	BUTT	TESTING	FTO	MOV	BAD LIMIT SWITCH
QTR	850416	BA	3	RV6	ECI	-0-	-0-	?	-0-	-0-	RUP DIAPHRAGM
QTR	840807	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	860831	BA	4	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?
SER	820207	BA	4	31760MV1G	SDS2	ISO	GLOBE	?	INL	AIR	FAILED O-RING
QTR	821117	BA	3	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	830204	BA	2	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	830203	BA	3	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	STICKING
SER	830830	BA	1	31760MV1H	SDS2	ISO	GLOBE	PROCESS TRANS	INL	AIR	O-RING FAILURE
QTR	830913	BA	4	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?
QTR	850000	BA	4	31760MV1J	SDS2	ISO	GLOBE	?	INL	AIR	?
QTR	821225	BA	3	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	830514	BA	2	31760V28	SDS2	ISO	GATE	TESTING	FTC	-0-	STEM STIFF
QTR	850712	BA	4	31760PV7	SDS2	CON	GLOBE	?	INL	SELF	?
QTR	851210	BA	1	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	STICKING
QTR	850624	BA	4	31760PV7	SDS2	CON	GLOBE	?	-0-	SELF	?
QTR	821206	BA	4	31760PV7	SDS2	CON	GLOBE	?	INL	SELF	?
QTR	820924	BA	2	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	861027	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	840909	BA	2	31760PV7	SDS2	CON	GLOBE	?	EXL	SELF	?
QTR	860713	BA	1	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	851230	BA	2	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	821019	BA	3	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	840805	BA	3	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	820126	BA	4	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?
QTR	860412	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	830126	BA	2	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	860906	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	830421	BA	4	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	830729	BA	1	31760MV2H	SDS2	ISO	GLOBE	?	INL	AIR	?

PROJECT 414 - AECB DATA BASE PART 2 - FAILURE POPULATION

SRC	FDATE	SITE	UNIT	USI-CODE	SYS	FUNCTION	TYPE	DISCOVERY	FMODE	ACTUATOR	FCAUSE
QTR	820108	BA	4	31760PV7	SDS2	CON	GLOBE	?	EXL	SELF	?
QTR	841120	BA	3	31760MV1G	SDS2	ISO	GLOBE	TESTING	SLOW	AIR	LACK OF LUB
QTR	820915	BA	1	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	821217	BA	2	31760MV3G	SDS2	ISO	GLOBE	-0-	-0-	-0-	-0-
QTR	821026	BA	3	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	860903	BA	1	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	851014	BA	1	31760PV7	SDS2	CON	GLOBE	TESTING	-0-	SELF	STICKING
QTR	850310	BA	4	31760PRV31	SDS2	CON	-0-	?	IMOP	-0-	?
QTR	831118	BA	3	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	830704	BA	2	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?
QTR	850705	BA	4	31760PV7	SDS2	CON	GLOBE	?	INL	SELF	?
QTR	860415	BA	4	PRV	SDS2	-0-	-0-	?	L	-0-	?
QTR	850928	BA	3	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	STICKING
QTR	830516	BA	1	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	840100	BA	3	31760PRV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	BAD VALVE SEAT
QTR	841205	BA	4	31760PV7	SDS2	CON	GLOBE	?	FTC	SELF	?
QTR	820128	BA	4	31760RV6	SDS2	PRV	GLOBE	TESTING	INL	SELF	?
QTR	820111	BA	3	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	830210	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
SER	820216	BA	4	31760MV1G	SDS2	ISO	GLOBE	?	INL	AIR	?
QTR	821023	BA	3	31760PRV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	851106	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	830902	BA	1	31760PV7	SDS2	CON	GLOBE	?	L	SELF	RUP DIAPHRAGM
QTR	840600	BA	0	31670NV1G	SDS2	ISO	GLOBE	?	INL	AIR	BAD O-RING
QTR	820825	BA	3	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?
QTR	850717	BA	3	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	860129	BA	1	3176PRV31	SDS2	CON	-0-	PROCESS TRANS	IMOP	-0-	STICKING
QTR	821109	BA	3	31760PRV31	SDS2	CON	-0-	?	INL	-0-	?
QTR	830503	BA	4	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	860518	BA	4	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?
QTR	830917	BA	3	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?

PROJECT 414 - AECB DATA BASE PART 2 - FAILURE POPULATION

SRC	FDATE	SITE	UNIT	USI-CODE	SYS	FUNCTION	TYPE	DISCOVERY	FMODE	ACTUATOR	FCAUSE
QTR	840400	BA	3	31670PRV7	SDS2	CON	GLOBE	?	INL	SELF	?
QTR	841120	BA	3	31760MV2G	SDS2	ISO	GLOBE	TESTING	SLOW	AIR	LACK OF LUB
QTR	860414	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	RUP DIAPHRAGM
QTR	821018	BA	3	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	830104	BA	2	31760PV7	SDS2	CON	GLOBE	?	IMOP	SELF	?
QTR	860630	BA	4	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	860526	BA	1	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	850908	BA	2	31760PV7	SDS2	CON	GLOBE	?	INL	SELF	?
QTR	860130	BA	2	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	831210	BA	4	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	850620	BA	4	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	850509	BA	3	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	831019	BA	4	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	831025	BA	3	31760PV7	SDS2	CON	GLOBE	?	EXL	SELF	?
QTR	831113	BA	1	31760PV7	SDS2	CON	GLOBE	?	INL	SELF	?
QTR	821123	BA	4	31760PV7	SDS2	CON	GLOBE	?	PTO	SELF	?
QTR	861208	BA	2	31760PV7	SDS2	CON	GLOBE	?	L	SELF	?
QTR	850219	BB	0	34340RV135	CONT	PRV	BUTT	ACCIDENTAL	INL	-0-	?
QTR	850519	BB	0	62412NFF2	CONT	CHK	-0-	TESTING	INL	-0-	?
QTR	850519	BB	0	62412NVF1	CONT	CHK	-0-	TESTING	INL	-0-	?
QTR	860210	BB	0	34340VI66	ECI	ISO	GATE	PROCESS TRANS	INL	MAN	?
SER	860427	BB	0	34340MV324	ECI	ISO	GATE	PROCESS TRANS	IMOP	HYD	O-RING FAILURE
QTR	850110	BB	0	34340NV103	ECI	ISO	BUTT	TESTING	INL	MOV	?
QTR	850409	BB	0	34340NV103	ECI	ISO	BUTT	TESTING	INL	MOV	?
QTR	841115	BB	0	34340MV103	ECI	ISO	BUTT	PROCESS TRANS	INL	MOV	?
QTR	861106	BB	0	34340MV303	ECI	ISO	BUTT	TESTING	IMOP	AIR	DISC SLOPPY ON SHAFT
QTR	850602	BB	5	31760PVA1	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	RUP DIAPHRAGM
QTR	850202	BB	6	31760RV5	SDS2	PRV	GLOBE	ACCIDENTAL	PTO	SELF	?
SER	840614	BB	6	31760MV1G	SDS2	ISO	GLOBE	TESTING	INL	AIR	?
QTR	850131	BB	5	31670PRV1	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	841117	BB	6	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?

PROJECT 414 - AECB DATA BASE PART 2 - FAILURE POPULATION

SRC	FDATE	SITE	UNIT	USI-CODE	SYS	FUNCTION	TYPE	DISCOVERY	FMODE	ACTUATOR	FCAUSE
QTR	860116	BB	5	31760PV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
SER	840401	PA	0	34220MV48	CONT	ISO	-0-	TESTING	FO	AIR	MECH FAILURE
QTR	840331	PA	0	34220MV48	CONT	ISO	-0-	TESTING	EXL	AIR	RUP DIAPHRAGM
QTR	820701	PA	3	33350NV453	ECI	CHK	BUTT	ACCIDENTA	FO	-0-	SEIZED
QTR	860210	PA	3	36110MV41	ECI	-0-	-0-	?	EXL	-0-	FAILED GASKET
QTR	850816	PA	3	71310V554	ECI	-0-	-0-	?	INL	-0-	ERODED BUTTERFLY
QTR	820622	PA	3	72110NV547	ECI	CHK	-0-	TESTING	INL	-0-	?
QTR	830502	PA	1	36110V163	ECI	ISO	-0-	TESTING	INL	-0-	?
SER	860913	PB	8	34230MV104	CONT	ISO	BUTT	TESTING	FTO	MOV	LACK OF LUB
SER	841223	PB	0	34960MV311	CONT	ISO	-0-	TESTING	FTC	AIR	?
QTR	851007	PB	5	33350MV41	ECI	ISO	BUTT	TESTING	FO	MOV	BAD TORQUE SWITCH
SER	840930	PB	5	33350MV66	ECI	ISO	BUTT	ACCIDENTAL	FTC	MOV	BAD TORQUE SWITCH
QTR	860825	PB	7	33350MV61	ECI	ISO	BUTT	TESTING	FTC	MOV	BAD TORQUE SWITCH
QTR	861229	PB	5	33350MV41	ECI	ISO	BUTT	TESTING	FTC	MOV	BAD LIMIT SWITCH
QTR	850105	PB	5	33350NV4	ECI	CHK	SWING	PROCESS TRANS	INL	-0-	?
SER	840927	PB	5	34700MV3J	SDS2	ISO	GLOBE	PROCESS TRANS	INL	AIR	?
SER	830927	PB	6	34700MV3J	SDS2	ISO	GLOBE	PROCESS TRANS	INL	AIR	?
QTR	841130	PB	5	34700PRV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
SER	860105	PB	8	34700PRV7	SDS2	CON	GLOBE	PROCESS TRANS	IMOP	SELF	?
QTR	860426	PB	6	34700MV2G	SDS2	ISO	GLOBE	TESTING	SLOW	AIR	LACK OF LUB
SER	830202	PB	5	34700MV1J	SDS2	ISO	GLOBE	PROCESS TRANS	INL	AIR	?

PART III - DESIGN DATA

LEAD SHEET

DESCRIPTION: Valve design data by site/USI No. as collected from review of design manuals at CNS of O.H.

SYSTEMS: ECC, SDS2, CONT.

SITES: Pickering A, Pickering B, Bruce A, Bruce B.

COLUMN HEADINGS	CONTENTS
USI	- USI NO.
CODE	- COMPONENT CODE
TYPE	- BALL, BUTTERFLY, GATE, GLOBE
SIZE	- NOMINAL SIZE IN INCHES
MANUFACTURER	- MISC. ENTRIES
MATERIAL	- MISC. ENTRIES
ACTUATOR	- AIR, HYD, MAN, MOV, SELF, SOL
FLUID	- PROCESS FLUID
TEMP	- DESIGN TEMPERATURE OF
PRES	- DESIGN PRESSURE (PSI)
DIFFER-PRES	- DIFFERENTIAL PRESS (PSI)

AECB VALVE STUDY
DATA BASE PART 3 - DESIGN DATA

STN	USI	CODE	TYPE	NOMINAL SIZE (INCH)	MANUFACTURER	MATERIAL BODY	MATERIAL BONNET	MATERIAL STEM	MATERIAL SEAT	ACTUATOR TYPE	PROCESS FLUID	DESIGN TEMP. (DEG. F)	DESIGN PRESSURE (PSIG)	DIFFER. PRESSURE (PSIG)
PA	3211	CV2		14.						AIR	D2O	150	11	4
PA	3211	CV26		14.						AIR	D2O	150	11	4
PA	3211	CV48		10.						AIR	D2O	150	69	20
PA	3211	CV50		10.						AIR	D2O	150	69	20
PA	3211	CV54		10.						AIR	D2O	150	69	20
PA	3211	CV55		10.						AIR	D2O	150	69	20
PA	3211	MV9	GATE	10.						MOV		155	25	5
PA	3312	MV42	GATE	4.		CS	CS			MOV	D2O	0	1600	1600
PA	3312	MV43	GATE	4.		CS	CS			MOV	D2O	-0-	1600	1600
PA	3335	CV450	BUTT	0.						AIR		-0-	-0-	-0-
*PA	3335	NV4	chk	16.		CS	CS				D2O&H2O	220	300	-0-
*PA	3341	MV1	GATE	10.		CS				MOV	D2O	571	1600	300
PA	3341	MV10	GATE	10.		CS				MOV	D2O	571	1600	300
PA	3341	MV11	GATE	10.		CS				MOV	D2O	571	1600	300
PA	3341	MV2	GATE	10.		CS				MOV	D2O	571	1600	300
PA	3341	MV4	GATE	10.		CS				MOV	D2O	571	1600	300
PA	3341	MV5	GATE	10.		CS				MOV	D2O	571	1600	300
PA	3341	MV7	GATE	10.		CS	-0-	-0-	-0-	MOV	D2O	571	1600	300
PA	3341	MV8	GATE	10.		CS	-0-	-0-	-0-	MOV	D2O	571	1600	300
PA	3341	V57	GLOBE	0.75		CS	CS	-0-	-0-		D2O	515	1500	1500
PA	3431	MV2	-0-	-0-		-0-	-0-	-0-	-0-	MOV		-0-	-0-	-0-
BA	3433	MV13	GATE	12.	HOPKINSON	A216	A216	-0-	PLATNA	MOV		595	1575	1575
*BA	3433	MV14	GATE	12.	HOPKINSON	A216	A216	-0-	PLATNA	MOV		595	1575	1575
*BA	3433	MV15	GATE	12.	HOPKINSON	A216	A216	-0-	PLATNA	MOV		595	1575	1575
*BA	3433	MV16	GATE	12.	HOPKINSON	A216	A216		PLATNA	MOV		595	1575	1575
*BA	3433	MV2	GATE	22.	DIKKERS	CS	CS			HYD		526	1690	1690
*BA	3433	MV3	GATE	22.	PEACOCK/HOPKIN	A216	A216	PLATNA	PLATNA	HYD	D2O	526	1690	1690
BA	3433	MV4	GATE	12.	HOPKINSON	A216	A216		PLATNA	MOV		595	1575	1575
BA	3433	MV5	GATE	12.	HOPKINSON	A216	A216		PLATNA	MOV		595	1575	1575
BA	3433	MV6	GATE	12.	HOPKINSON	A216	A216		PLATNA	MOV		595	1575	1575
BA	3433	MV7	GATE	12.	HOPKINSON	A216	A216		PLATNA	MOV		595	1575	1575
*BB	3434	MV103	BUTTERFLY	36.	JAMESBURY	CS	CS			MOV	H2O+D2O	220	225	225

	STN	USI	CODE	TYPE	NOMINAL SIZE (INCH)	MANUFACTURER	.....MATERIAL..... BODY	BONNET	STEM	SEAT	ACTUATOR TYPE	PROCESS FLUID		DESIGN TEMP. (DEG. F)	DESIGN PRESSURE (PSIG)	DIFFER. PRESSURE (PSIG)
	BB	3434	MV104	BUTTERFLY	36.	JAMESBURY	CS	CS			MOV	H2O+D2O		220	225	225
	BB	3434	MV113	BUTTERFLY	36.	JAMESBURY	CS	CS			MOV	H2O+D2O		220	225	225
*	BB	3434	MV114	BUTTERFLY	36.	JAMESBURY	CS	CS			MOV	H2O+D2O		220	225	225
*	BB	3434	MV303	BUTTERFLY	16.		316SS	316SS		KEL F	AIR	NITROGEN		150	900	900
	BB	3434	MV304	BUTTERFLY	16.		316SS	316SS		KEL F	AIR	NITROGEN		150	900	900
*	BA	3434	MV313	GATE	24.	ROCKWELL	CS	CS		STELLI	HYD			220	1200	800
	BA	3434	MV314	GATE	24.	ROCKWELL	CS	CS		STELLI	HYD			220	1200	800
	BA	3434	MV323	GATE	24.	ROCKWELL	CS	CS		STELLI	HYD			220	1200	800
*	BA	3434	MV324	GATE	24.	ROCKWELL	CS	CS		STELLI	HYD			220	1200	800
	BB	3434	RV133	prv	1.5	DRESSER	SS			SS		H2O		220	225	-0-
	BB	3434	RV134	prv	1.5	DRESSER	SS			SS		H2O		220	225	-0-
*	BB	3434	RV135	prv	1.5	DRESSER	SS			SS		H2O		220	225	-0-
	BB	3434	RV136	prv	1.5	DRESSER	SS			SS		H2O		22.	225	-0-
*	BB	3434	V166	GATE	30.	ROCKWELL	CS	CS		STELLI	MAN			220	1200	1200
	BB	3434	V167	GATE	30.	ROCKWELL	CS	CS		STELLI	MAN			220	1200	1200
	BB	3434	V169	GATE	30.	ROCKWELL	CS	CS		STELLI	MAN			220	1200	1200
	BB	3434	V170	GATE	30.	ROCKWELL	CS	CS		STELLI	MAN			220	1200	1200
	PB	3471	MV1	GLOBE	3.		CS	SS	17-4	NYLON	AIR			100	1440	1440
	PB	3471	MV1G	GLOBE	0.375		SS	SS			AIR			100	1440	1440
	PB	3471	MV1H	GLOBE	0.375		SS	SS			AIR			100	1440	1440
	PB	3471	MV1J	GLOBE	0.375		SS	SS			AIR			100	1440	1440
	PB	3471	MV2	GLOBE	3.		SS	SS	17-4	NYLON	AIR			100	1440	1440
	PB	3471	MV2G	GLOBE	0.375		SS	SS			AIR			100	1440	1440
	PB	3471	MV2H	GLOVE	0.375		SS	SS			AIR			100	1440	1440
	PB	3471	MV2J	GLOBE	0.375		SS	SS			AIR			100	1440	1440
	PB	3471	MV3G	GLOBE	0.375		SS	SS			AIR			150	1400	1400
	PB	3471	MV3H	GLOBE	0.375		SS	SS			AIR			150	1400	1400
	PB	3471	MV3J	GLOBE	0.375		SS	SS			AIR			150	1400	1400
*	PB	3611	MV41		8.							STEAM	-0-		570	570
	PB	3611	MV45		8.							STEAM	-0-		570	570
*	PB	33350	MV41	GATE	10.		CS	CS			MOV	D2O	-0-		1600	1600
*	PB	33350	MV61	GATE	10.		CS	CS			MOV	D2O		1600	0	1600
*	PB	33350	MV66	GATE	10.		CS	CS			MOV	D2O	-0-		1600	1600
*	PB	34230	MV104	BUTTERFLY	18.	JAMESBURY					MOV	AIR		122	6	15

STN	USI	CODE	TYPE	NOMINAL SIZE (INCH)	MANUFACTURER	.....MATERIAL..... BODY	BONNET	STEM	SEAT	ACTUATOR TYPE	PROCESS FLUID	DESIGN TEMP. (DEG. F)	DESIGN PRESSURE (PSIG)	DIFFER. PRESSURE (PSIG)
PB	34230	MV115	BUTTERFLY	18.	JAMESBURY					MOV	AIR	122	6	15
*BA	34340	MV367	BUTTERFLY	30.	JAMESBURY	CS	CS		EPDM	MOV	WATER	220	225	225
BA	34340	MV368	BUTTERFLY	30.	JAMESBURY	CS	CS		EPDM	MOV	WATER	220	225	225
*BA	34340	PRV344	PRV	0.5		BRASS	BRASS		NEOPRE	SELF	NITROGEN	140	2200	2200
*BA	3434	mv103	butterfly	36.	JAMESBURY	CS	CS			MOV	H2O	220	225	225
BA	3434	mv104	butterfly	36.	JAMESBURY	CS	CS			MOV	H2O&D2O	220	225	225
BA	3434	mv113	butterfly	36.	JAMESBURY					MOV	H2O&D2O	220	225	225
*BA	3434	mv114	butterfly	36.	JAMESBURY					MOV	H2O&D2O	220	225	225

- Total number of valves in this D.B. = 74

- Valves without asterisks above did not have any failures for the reporting period of this report = 51

- Valves with asterisks above did have failures for the reporting period of this report = 23

APPENDIX C

LIST OF RELEVANT

IN SERVICE REPORTS

ONTARIO HYDRO IN-SERVICE REPORTS REVIEWED

REPORT	TITLE
IR-03660-22	NED Operating Experience with Electrically Operated Valves.
IR-31760	Repair and Modification of the Quick Acting Type: Fisher 472-1-AC.
IR-31760-2	Failure of Sealing Discs on Fisher Quick Acting Valves.
IR-32133-1	Replacement of Packing on Moderator Control Valves.
IR-33000-7	Failure of Charging Pump Check Valve to Close on Class IV Power Failure - Detailed Investigations of Damage to NPD Systems.
IR-33000-8	Modification of Check Valve PH-NV12.
IR-33023	Failure of the 3/8" Newman Hender Tandem Valves.
IR-33320-5	Heat Transport Control Valves.
IR-333413	Isolating Valves Failures - Mechanical.
IR-33350-3	ECI Valves Operated by Limitorque Activators History of Problems and Summary of Performance Improvement Program.
IR-33361-1	Investigation into Sticking of Main Heat Transport Relief Valve, September 19, 1976.
IR-33411	Replacement of Two Suspected Faulty Systems in 10" Velan Gate Valve.
IR-33611	On-Power Testing of H.T. Relief Valves.
IR-34330-1	Limit and Torque Switch Problems on ECI Valves.
IR-34330-2	Installation of a Hydraulic Actuator on ECI Valve 3433-MV3.
IR-34330-3	ECI Valves Stroking Test.

REPORT	TITLE
IR-34340-1	Recovery SUMP Isolation Valves Leakage BGB-34340-1.
IR-34340-4	Accumulator Gas Tank Isolating Valves BGB-34340-4.

APPENDIX D

MOVATS'S INSTRUMENTATION PACKAGE [16]

MOVATS is a portable signature-analysis device marketed by MOVATS, Inc. of Marietta, Georgia. It is designed to indicate to the user the general mechanical condition and the electrical control setup of motor-operated valves. Signatures of relative thrust, control switch actuation, and motor current, all superimposed on each other, can be interpreted by the test equipment to indicate performance degradation in the valve, operator, control circuit, or motor, prior to an actual failure.

This system gathers, stores, analyses, and provides hard copies of the following valve operating parameters.

- Axial motion of the worm gear
- Actuation points of the control systems' limit and torque switches
- Dynamic motor current

The above signatures are collected while the valve is cycled under ambient conditions.

Stem Thrust Signature

In an MOV actuator, the thrust for stroking the valve is delivered to the stem from the electric motor via a gearbox. This gearbox includes a worm and worm gear to increase the drive torque available from the motor. The worm is keyed onto a shaft with spines and its axial movement is restrained by a spring pack. The torque transferred by the worm to the worm gear causes the worm to move axially along its shaft and so compresses the spring pack. As a result, during valve operation the axial displacement of the worm is proportional to the torque being delivered to the worm gear. The MOVATS system obtains the stem thrust signature by accurately measuring the instantaneous axial motion of the worm throughout a valve cycle.

To measure the axial displacement of the worm, a LVDT (linear variable differential transformer) is used in a device known as the TMD (thrust measuring device). The TMD is mounted across the worm spring pack allowing the axial displacement of the worm to be measured as a voltage.

The spring pack is installed with a preload against the worm. Thus the spring pack starts to compress only when the axial thrust of the worm exceeds the spring pack preload. Thus a zero TMD voltage can represent any thrust less than the spring pack preload.

The output voltage of the TMD can be used directly to assess the mechanical condition of the valve and operator. In order to measure the actual thrust however the TMD output must be calibrated. This step is necessary to determine properly the spring pack preload and torque switch setpoints. The calibration is performed using a MOVATS system thrust calibration fixture. This device allows the mounting of a load cell between the top of the valve stem and the fixture which is mounted on the operator housing. The valve is operated electrically and the rising stem contacts the load cell and causes the worm to move axially against the spring pack. The output of the load cell is then plotted against the output of the TMD. The resultant curve represents the spring pack calibration in pounds of stem thrust per volt of TMD output.

Control Switch Actuation Points

To obtain the exact times during the valve cycle that the limit and torque switches operate, a specially designed multicoil transformer device allows the MOVATS equipment to produce a signature of the switch actuation during a valve cycle. By superimposing this signature on the thrust signature, the exact points and loading conditions at which the switches actuate are determined.

An alternative method is available which does not require

interference with the operator control wiring. This method however requires observation of the torque switch actuation during part of the valve cycle.

Motor Current Signature

This parameter is recorded by using a clamp-on ammeter with an analog output. The meter may be placed at the valve operator or its motor control centre, whichever is most convenient.

Signature Analysis

From the above signatures it is possible to determine the following characteristics during a valve stroke:

Stem Thrust Signature:

- Spring pack relaxation. Occurs as the motor unwinds the spring pack tension created during the previous closing stroke.
- Zero worm deflection. Occurs after spring pack relaxation and before stem drive is picked up.
- Hammerblow. Load required to unseat the valve.
- Running Load. Thrust required to overcome packing and gear friction.
- Valve Seating.
- Load at torque switch trip.
- Total thrust. Max stem thrust produced by the valve operator for a given torque switch setting.
- Available thrust. Total thrust minus running load.
- Valve cycle time.

Switch Signatures:

- Time at which the close to open bypass switch opens.
- Time at which the torque switch opens momentarily due to hammerblow.
- Time at which the limit switch opens and shuts down the motor.

Motor-current Signature:

- Starting current
- Hammerblow
- Running motor current

APPENDIX E

MOTOR CURRENT ANALYSIS OF MOTOR OPERATED VALVES [17]

Research at ORNL has shown that the motor current signature of an MOV contains four levels of information:

- Mean value over a valve stroke
- Gross variations during a valve stroke
- Transients
- Frequency spectrum of periodic variations.

By analyzing all four levels of information it is expected that many types of age-related degradation of MOVs can be detected and trended.

To measure the motor current signature, a clamp-on ammeter is used with an analog output. This device is placed around one of the current carrying conductors of the MOV supply cable. It may be placed in any position between the MOV control center and the motor. No interruption of the supply or control wiring is necessary which means the MOV on test is never inoperative.

Mean Value of Motor Current

This is the lowest level of information in a motor current signature. The mean value of the current drawn by an MOV actuator during any stroke depends on the following:

- Friction in the valve operator (gearbox)
- Friction in the valve body
- Fluid pressure in the valve body
- Fluid differential pressure across the valve obturator
- Supply voltage

Tests at ORNL have demonstrated that relationships clearly exist between the above parameters and the mean motor current. A typical use for this data is to trend with time the valve seating margin (total thrust minus thrust required to stroke the valve) which may be used to determine aging of the valve mechanical parts.

Gross Variations

Analysis of this characteristic can indicate variations in valve stem diameter and valve packing tightness.

Transients

The transients in a motor current signature can be used to detect operational degradation and enable the setting up of the control torque and bypass switches.

The first transient seen on a close to open motor current signature is the hammerblow caused by the drive lugs engaging in the operator gearbox. The second hammerblow is caused by the torque required to unseat the valve as the obturator begins to move. Trending of these transients allows aging related problems to be detected. The position and magnitude of the transients allows the control bypass and torque switches to be set. This method is superior to measuring the spring pack deflection (MOVATS) or listening to the hammerblows because both methods require direct access to the valve whereas the motor current signature method does not. Also, the spring pack deflection current signatures would also produce a similar vibration signature.

Frequency Spectrum of Periodic Variations

Vibration signatures can be processed by passing them through a Fast Fourier Transform (FFT) analyzer and comparing them for information content with similarly processed motor current signatures. Both signatures show spectra peaks at the same frequencies although the relative magnitudes of the peaks differ. The reasons for these differences are believed to be due to the following:

- The motor current reflects only load generated spectra but an accelerometer output may include spectra from other equipment causing valve vibration.

- The accelerometer can detect vibrations in one plane only whereas the current signature will detect all load changes.

- The motor current transducer is directly connected to the load. The accelerometer however is physically connected via various materials and joints which may "colour" the spectra. Overall, the motor current analysis technique is superior to the vibration analysis technique because the former does not require direct access to the valve itself and contains information on the motor slip speed [17].

APPENDIX F

U.S. VALVE FAILURE DATA SOURCES

1 Licensee Event Reports (LERs)

LER forms are used by US nuclear operating facilities to advise the NRC (Nuclear Regulatory Commission) of ROs (Reportable Occurrences). This system is much like the SER or UER system used in Canada to advise the AECB of significant events. Events that are considered reportable are specified in the licensee's Technical Specifications and/or licence provisions. Events that result in damage to major equipment, or cause extended unit outages are usually reported. Other events which are not required to be reported, that is do not involve safety related equipment, are sometimes written on an LER and marked for information only.

The purpose of the LER is to provide a quick means of reporting the details surrounding a RO. It is intended to provide an abstract of the event to assist in identification of generic problems, and to aid in the subsequent investigations.

The following information is available from an LER regarding age-related equipment failure:

- Plant docket number and event date
- Event description and probable consequences
- Cause description and corrective action
- System code
- Cause code
- Cause subcode
- Component code
- Component subcode
- Valve subcode (if applicable)
- Action taken
- Effect on plant
- Shutdown method

- Method of discovery
- Discovery description

For most RO's a supplementary report is included with the LER to expand on the information given on the form. If new information is received regarding the RO after the LER is issued, it will be revised and re-submitted by the utility. This is in contrast to the SER/UER system which as a rule, is not revised once issued.

Studies using LER data to identify aging trends have shown that the LER system is not a good engineering data collection device. Information such as equipment age, service life and environment is seldom included because the author is not required to record such data. As a result, analysis performed using LER data must take into account its non-statistical nature [2].

2. Nuclear Operations Analysis Center (NOAC)

NOAC has stored abstracts of LERs and their predecessors on a database which has become the official reference for the NRC. This database is accessible through the RECON (REmote CONsole) program maintained by the DOE (Department of Energy). RECON is an interactive information retrieval system designed to give quick access to energy-related database from various locations across the US. The NOAC database also contains information on nuclear power plant safety, operating experience, licencing data, and design.

The desired subject matter can be referenced by using key words and keyed fields in combination. This permits searching for failure events involving specific components such as valves and valve operators.[2][18]

3. Nuclear Plant Reliability Data System (NPRDS)

The NPRDS is a large on-line database operated by INPO (Institute of Nuclear Power Operation) and contains component engineering and failure data available by special request. Input to NPRDS is

done on a voluntary basis by INPO member utilities and contains many entries not reportable in LER's. The database contains no failure event reference however or plant identification which means the data obtained from NPRDS cannot be cross-referenced with other sources.

For each failure event the following information is available:

- Service data
- Manufacturer
- Model number
- Discovery date
- Type of failure
- Failure mode
- Failure cause
- Method of detection
- Narrative of failure cause, descriptions and corrective action

NPRDS produces an annual report that contains generic cumulative component reliability data. [18]

4. In-Plant Reliability Data System (IPRDS)

The IPRDS database contains failure and repair information from plant corrective maintenance work requests. The primary objective of this system is to establish a comprehensive source of information for reliability analysis. This information contains the following:

- Component type
- Vendor
- Population
- Plant mode
- Failure cause (if reported)

- Failure mode
- Repair data
- Failure severity
- Incipient failure detection

Information useful for incipient failure detection can be gleaned from this database because it contains for components which have not failed as well as actions resulting from component failures. Failed pats and failure mechanisms are not recorded as separate entries in the database but this information is sometimes available from the narrative of each event. [18]

5. Nuclear Power Experience (NPE)

This is a document produced monthly by the S.M. Stroller Corporation which contains operating experience of US light-water nuclear power plants. The document consists of a number of loose leaf volumes crosss-referenced and keyworded for information access and retrieval. The data is compiled from numerous publications and sent to the subscribers of the system.

The publication includes comprehensive narratives of failure events compiled from LERs and other sources. The failure entries include references to the source of the data, the event date and the plant.